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THE

PRACTICAL MINER'S GUIDE.

Byers, Printer, Devonport.

S. H. 1825.

THE

PRACTICAL MINER'S GUIDE;

COMPRISING A SET OF

TRIGONOMETRICAL TABLES,

ADAPTED TO ALL THE PURPOSES OF

OBLIQUE OR DIAGONAL, VERTICAL, HORIZONTAL AND TRAVERSE

DIALLING,

WITH THEIR APPLICATION TO THE DIAL EXERCISE OF

SHAFTS, ADITS, DRIFTS, LODES, SLIDES, LEVELLING,
INACCESSIBLE DISTANCES, HEIGHTS, &c.

ALSO

A TREATISE

ON THE ART AND PRACTICE OF ASSAYING SILVER, COPPER, LEAD, AND TIN,
WITH TABLES WHICH EXHIBIT AT ONE VIEW THE VALUE OF ASSAYED ORES:
RULES FOR CALCULATING THE POWER OF STEAM AND WATER ENGINES:
A DISCOURSE ON THE QUALITY, MANUFACTURE, AND
CHOICE OF CORDAGE FOR MINE SERVICE:

TOGETHER WITH A COLLECTION OF ESSENTIAL

TABLES, RULES, AND ILLUSTRATIONS,

EXCLUSIVELY APPLICABLE TO

MINING BUSINESS.

THE WHOLE INTRODUCED AND EXEMPLIFIED IN THE MOST PLAIN AND
PRACTICABLE MANNER.

BY J. BUDGE.

LONDON:

LONGMAN, HURST, REES, ORME, BROWN, AND GREEN;

AND

W. BYERS, DEVONPORT.

1825.

(Entered at Stationer's Hall.)

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BIBLIOTHECA · BODLEIANA

TO

BENJAMIN TUCKER, Esq.

SURVEYOR-GENERAL OF THE DUCHY OF CORNWALL.

AND

JOHN TAYLOR, Esq.

DIRECTOR OF BRITISH AND FOREIGN MINING INSTITUTIONS.

Gentlemen,

The propriety of composing an address under this head did not, until of late, occur to my imagination, and with much trepidity and circumspection do I now attempt the difficult task. My apprehensions arise from a consciousness of the extreme delicacy of the undertaking, and the danger I have to encounter, arising from the probability of a misconstruction being put on the sentiments I may advance; nevertheless I feel an enlivening hope, springing up as I proceed, that I shall not be unhappy enough to make an insertion of a single sentence but what you will either approve or palliate, and this point secured I shall be comparatively indifferent of all other consequences.

DEDICATION.

The succeeding remarks will prove explanatory of my motives, and I trust will be deemed a satisfactory apology for my adventuring into the dedicatory labyrinth, from whence but few escape without considerable loss in the estimation of the most discerning part of their readers.

It is a prevalent opinion that gentlemen sometimes allow authors to make an ostentatious display of their influential names in the front of their works, while at the same time they possess not the slightest knowledge of the composition, or of ever having seen a line thereof, until a finished copy has been formally presented them, adorned with their illustrious names and the writer's adulatory compliments; but further, it is notorious that composers, not unfrequently, take the unwarrantable franchise of introducing the honorable names of eminent persons for this purpose without ever obtaining, or even soliciting, their permission for so doing.

These considerations have induced me, with great diffidence and contrary to my preconception of the matter, to frame this respectful address, for after mature deliberation I have been led to conclude, that it would be doing an act of injustice to you, to myself, and to those who may be interested in the contents of this volume, were I to forbear giving publicity to the fact, that it was not until you had investigated the most essential parts of the manuscript, and felt assured that it was calculated to answer the end designed, and thereby prove advantageous to the mining interest, that you consented to honor it with your countenance, and allow your respected names to be introduced in a patronal capacity.

Without fear of the imputation of flattery, I may with confidence remark that your great experience, knowledge, celebrity, and interest in mining affairs, are calculated to inspire a reasonable hope, that through your support and precedent, success will attend my humble efforts, and I shall ultimately obtain a fair pecuniary remuneration for my labours; but, necessitous as I am, the animating thought of my exertions becoming instrumental in yielding an important benefit to a considerable and most useful class of my fellow men, is by far the greatest cause of my exultation.

It now only remains for me to acknowledge the obligations I feel, not for mere nominal patronage, but for the actual assistance I have received at your hands, whereby I have been enabled to overcome the formidable obstacles which presented themselves against the accomplishment of this difficult and embarrassing enterprise. And at the same time I would not dare neglect to return my unfeigned thanks, in the most undisguised and solemn manner, to that supreme and gracious Power whose benign and omnipotent influence has been manifestly exercised in my behalf throughout the arduous undertaking.

Possibly this digression may be condemned as unseasonable, unsuitable, and unfashionable, *by those who fancy themselves too wise and independent to allow it to be obligatory upon them openly to acknowledge the aid of Divine Providence in all their successful engagements; but desirous as I am of giving universal satisfaction, far rather will I endure the scorn and sarcasms of such individuals, than avoid their contumely* *at the expence of an approving conscience, and the approbation of the truly wise and honorable.*

In conclusion, I sincerely beg excuse for the almost unprecedented latitude I have unintentionally taken for this subject, and allow me most cordially to congratulate you on the high degree of respectablity as well as the national utility and importance the mining system of Great Britain has recently acquired, and to which, it is generally acknowledged, your example and instrumentality have materially contributed.

That you may live long and prosperously, and that uninterrupted success may attend your every endeavour to promote your own and the public welfare, is the sincere and hearty desire of

Gentlemen,

Your most grateful,

Most obedient,

and very humble servant,

THE AUTHOR.

PREFACE.

THROUGHOUT this little work the benefit of the Practical Miner has been constantly kept in view; and although the Tables may be successfully used on other occasions, yet we have professedly the mining interest solely for our object.

It is hoped that the curious examiner will find no flagrant violation of the rules of composition or mathematical order; but to any who may be disposed to search for defects we beg to state, that the work has been prosecuted and accomplished amidst numerous disadvantages, among which, the frequent interruptions arising from the almost incessant duties of a mining avocation have not been the least perplexing. But notwithstanding all this, we feel it incumbent on us to state, in defence of the calculations, that so far as Hutton's celebrated Logarithms, compared with those of other eminent authors, can be relied on as a foundation, together with the utmost care in, and repetition of, every single operation, supported by numerous subsequent proofs, both theoretical and practical, we are warranted in alledging our conviction, that the Tables may be received and applied to the most difficult and important operations in dialling, with the utmost confidence.

We now take a transient, but submissive leave of the Mine Agent, and respectfully address ourselves to persons in the capacity of Schoolmasters in mining districts.

To that respectable class of men this work is also recommended, as a fit subject for the study of those youths committed to their instruction, who appear designed for a mining occupation; and having ourselves had some years' experience in public teaching, we presume to declare our persuasion, that it is capable of being rendered extremely useful, by the prudent tuition of skilful preceptors. And why, we would enquire, should not the theory of the essential art of mining be taught in the seminaries of England, as well as in Mexico? (where, we understand, the colleges or schools of mines are among the most noble establishments of the empire); but especially in Cornwall, where the principal support of the county depends on the prosperity of the mines, and where much of that prosperity depends on the judicious management of those persons to whom the superintendency thereof is committed.

In conclusion we beg to remark, that we have generally used such terms as are common, and, in some cases, almost peculiar to mining business; believing that this phraseology will render the work far more intelligible and acceptable to the majority of those for whose use it is designed, than if we had confined ourselves to a precise mathematical mode of expression.

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EXPLANATION OF THE DIAGRAMS.

Table 1.—Page 33.

In this scheme the hypothenuse is made radius, consequently the other sides are the sine and cosine of the included angle.

Corollary.—Suppose one end of the line A B to remain at A while the other end B is moved round from *e* to *f*, then it is evident that the base C B will continue to increase, and the perpendicular B D to decrease, until the whole quadrant has been swept off.

At 45° or the middle of the quadrant, the base and perpendicular are equal, and from that point to 90° the base will increase in the same ratio as the perpendicular decreased from 1° to 45°; hence the propriety of the arrangement of this table in counting the degrees backward from 45 to 90.

Table 2.—Page 39.

Here the perpendicular is made radius, therefore the hypothenuse A C will be the secant, and the base B C the tangent of the angle A. On this principle it is clear that as the angle increases the base and hypothenuse will continue (throughout the whole quadrant) to increase in proportion.

Table 3.—Page 47.

In this diagram the base is made radius, therefore by mathematical demonstration the perpendicular A C is the co-tangent, and the hypothenuse B C the co-secant, of the angle C; and here it will be plain, that as the angle C is increased, the hypothenuse and perpendicular will, proportionably, be diminished.

ILLUSTRATION OF THE CHARACTERS.

$+$ *plus*, or *more*, the sign of addition; signifying that the numbers or quantities between which it is placed are to be added together.

— *minus*, or *less*, the sign of subtraction; denoting that the lesser of the two quantities between which it is placed is to be taken from the greater.

× *into*, the sign of multiplication; signifying that the quantities between which it is placed are to be multiplied together.

÷ *by*, the sign of division; signifying that the former of the two quantities between which it is placed is to be divided by the latter.

: *as*, or *to*, : : *so is*, the sign of an equality of ratios; denoting that the quantities between which they are placed are proportional to each other.

Thus, 2 : 3 : : 4 : 6, denotes that 2 is to 3 as 4 is to 6.

= *equal to*, the sign of equality; signifying that the quantities between which it is placed are equal to each other.

Thus, $6 + 4 = 10$, shews that 6 added to 4 is equal to 10.

∠ *Angle.*

° *Degrees.*

′ *Minutes.*

A given line is represented by a stroke or dash (!) as the base A B in the triangle on page 3, and a required line by a cypher, (o) as in the legs of the same triangle.

ABBREVIATIONS.

Deg.	Degrees.	E.	East.
Min.	Minutes.	W.	West.
Fath.	Fathoms.	Prob.	Problem.
Ft.	Feet.	Ex.	Example.
In.	Inches.	Ansr.	Answer.
Hyp.	Hypothenuse.	Dia.	Diameter.
Perp.	Perpendicular.	Cwt.	Hundred weight.
Comp.	Complement.	Qr.	Quarter.
Tab.	Tabular.	Lbs.	Pounds.
Dec.	Decimals.	Oz.	Ounces.
N.	North.	Dwt.	Pennyweight.
S.	South.	Grs.	Grains.

ERRATA.

Page 29 for 1666 . 8 read 200.

Page 85 for 2392145 read 2393145.

INTRODUCTION.

IT is an acknowledged fact, that dialling, in all its varieties, is the most difficult and momentous part of the duty of practical mine agents: to assist them in that important operation, is the chief design in giving publicity to these Tables.

Notwithstanding the great improvements which of late years have been made in the art of dialling, the most intelligent miners universally admit, that the practice is still very imperfect; nay, so far are they from any determinate and general system, that two persons can scarcely be found who precisely adopt the same method; consequently some plain scheme, founded on pure mathematical principles, is a great mining desideratum.

Aware of the opposition which is so apt to arise against all attempts at innovation of an old and established habit, (which however faulty in itself, custom may have stamped with an imaginary perfection), it may be necessary to make a few observations in support of this work, and endeavour to prove its advantages over all the preceding modes of performing a dialling operation in every respect.

INTRODUCTION.

Not many years ago the customary way of ascertaining the perpendicular and horizontal lines corresponding with a diagonal shaft, was by the very uncertain, expensive, and tardy practice of dropping a plumb line from the back to the bottom, there fixing a sollar or platform, and repeating the process from the brace to the foot of the shaft: this usage is largely explained in "Pryce's Treatise on Mines and Mining," (a celebrated work, published by subscription, about the year 1776) and therein described as the only system then known.

It is true this most objectionable measure is now exploded, but not without great reluctance by many of its old practitioners, who were long before they could be prevailed on to abandon it, notwithstanding its glaring inconveniencies, accompanied with the loss of time, waste of property, and hazard of their lives.

By inserting this defectibility of our predecessors, we have no other design than of cautioning our mining countrymen to guard against the too prevalent propensity of rejecting any new system, merely because it is *new*, or its utility not discerned at first sight; and to induce them to give the subject an impartial investigation, before they pass a conclusive judgment thereon.

The use of mathematical instruments is now partially known in the mining world; and, certainly, those agents who are well acquainted therewith, possess a decided advantage over others who are not; for, doubtless, this science has the pre-eminence, in a high degree, over every other method heretofore employed in dialling. But without intending to undervalue instrumental operation, we appeal to the experience of our scientific readers for support, in avouching that the process is ever liable to errors of considerable extent, and which are prone to slide in unaccountably: but it is a palpable fact, that in pointing or sweeping off the angles, an almost imperceptible deviation will create a serious departure from truth; and even in the course of bisecting, trisecting, inscribing, describing, and circumscribing; also in drawing parallels, raising or demitting perpendiculars, the operation, even with the greatest care, is exposed to considerable mistakes: and so sensible are all professional men of this defect, that instrumental operation is never resorted to, or relied on, in any case where great accuracy is required. But when we reflect on the laborious duties of the practical mine agent, and how much these duties are calculated to disqualify him for performing a geometrical plan with that delicacy and precision, which the operation so indispensably demands, we then become established in our opinion of the necessity of a work of this kind, and of its superiority over every other system hitherto introduced in dialling.

Should any be yet disposed to advocate the existing practice, and to contend that it is fully adequate to the desired purpose, we beg permission to enquire of such persons, why it is that mistakes so commonly occur in sinking shafts and driving levels in most of our mines? That irreparable errors do frequently happen, is a truth too notorious for contradiction or dispute, and sometimes even under the superintendence of men, whose knowledge, circumspection, and experience, no one presumes to call in question; consequently a more convincing proof than this cannot be adduced of the fallibility of the best modern practice, and the necessity for the introduction of a more perfect system.

Should it be enquired wherein the merit of this work is considered to consist, we answer, First,—*Accuracy*; and it will be discovered at a glance, that every operation of the principal tables is wrought out to five places of decimals, or the *ten thousandth part of an inch!* consequently we may affirm, without fear of confutation, that, in this property, we outvie every other system.

Secondly—*Plainness.* Of this quality our expert readers will be convinced at first sight, and will need no instruction for enabling them to apply the numbers readily; but we do not hesitate to say, that, by the help of the rules and examples, a common school-boy will find no insurmountable difficulty in solving the most abstruse problems relevant to dialling.

Thirdly—*Dispatch.* To this desirable property no other system has an equal claim, or can with any chance of success, enter into competition with our method; inasmuch as an answer, in most cases, may be obtained by the tables in less time than is necessary to make a preparation for performing the operation in any other way.

And now having briefly endeavoured to set forth the work in a true light, we commit it to the judgment of a liberal and discerning people; and should it be instrumental in happily preventing the grievous errors which are so prevalent in mining operations, (and which, we are bold to say must, in the nature of things, continue to take place by the present day practice); or should it only help to relieve the minds of faithful superintendents from that painful anxiety and suspense which never fail to harrass them during the progress of any considerable work, whereby a heavy responsibility rests on them for the accuracy of their dialling, or should it in any other way have the happy tendency of promoting the interest of mining, we shall not regret the labour, pain, expense, privation, trouble, and perplexity, it has cost us, even though we should never receive any other compensation,

EXPLANATION AND USE

OF THE

TABLES.

AFTER so many preliminary observations, it will be necessary to say but little under this head, having already anticipated several things by way of introduction, which properly belong here.

The reader will observe that the work is composed of three distinct tables, for the obvious reason of making each side of the triangle radius; and certainly without such an arrangement it would have been incomplete.

In each case the radius, or given side, is one fathom, being the most convenient and familiar proportion that could have been introduced.

The principal calculations include every quarter or fifteen minutes of a degree, and extend from 1 to 89 degrees, being sufficiently extensive and minute for mining purposes, (the angle of any intermediate division not being distinguished or required) and here, it must be observed, that the divisions are expressed by 15, 30, and 45 minutes, which numbers represent ¼, ½, and ¾ of a degree.

The first and most essential table is that wherein the hypothenuse, or longest side, is made radius, extending nearly throughout the quadrant, and every calculation wrought out to five decimal places of an inch, hereby giving a direct answer, in exact ratio to 6 feet of the given side, to the ten thousandth part of an inch.

Perhaps there may be a little difficulty at first, with persons unacquainted with mathematical order, in reading the first table. It must be remarked, that from 1° to 45°, or the middle of the quadrant, the degrees and parts are all on the left hand side descending, the base stands in the adjoining columns, and the perpendicular on the same line to the right; but beyond that point, the degrees will be found on the right hand side ascending, and then it must be specially noted that the perpendicular and base will have changed their positions, the base now standing on the right hand, and the perpendicular on the left hand side.

In the second table the perpendicular is given and the angles extend to 60 degrees. One valuable mining property of this table is, that it gives at sight the underlay in a fathom of every angle within the range of 60° including the divisions: so that if it is required to know the underlay in a fathom on any degree, or quarter of a degree, between

1 and 60; it will be immediately discovered by an inspection of the base in the column adjoining the given angle in this table.

In the third and last table the base is given, and as the application of this part of the work is not so general as the preceding, the angles have been given in degrees only: nevertheless this table is indispensable on some occasions, especially in levelling or driving adits. It will be found, like the second table, to extend from 1 to 60 degrees.

Having thus briefly stated the nature of the work under each separate head, it only remains for us, after a few general observations, to recommend the learner to the inspection of the following examples; for we believe that one practical operation will do more towards giving him a clear understanding or comprehension of the subject, than a volume written expressly thereon, confined to mere speculative description.

It may be remarked that, in almost every instance, the geometrical construction of the figure is introduced, with the calculation, which will tend to the satisfaction of the practitioner, and improvement of the beginner.

In conclusion we would remark, that the same attention must be paid in taking the angle, and measuring the given line, when these tables are used, as if the operation was performed any other way.

It is a common practice in mining to take the angle of underlaying shafts with the cover of the dial and a plumb-line; and in short drafts, with great care, this method may answer well enough: but when any very important work is to be performed, we would strongly recommend the application of a more perfect instrument for ascertaining the angle; for it is well known, that if this part of the process should not be correct, the result of the whole work must be erroneous as a matter of course; and indeed it is next to impossible to distinguish the minutia of an angle, with any tolerable degree of certainty, by the foregoing method. There doubtless are instruments much better adapted to the work, both for speed and accuracy, than the dial; and it is matter of surprise that they have not been more generally introduced in our mines: of these instruments the Theodolite certainly stands unrivalled, for taking both horizontal and vertical angles.

It is not our design to enter into controversy on this subject; those who imagine the sextant or quadrant graduated on the cover of the dial well calculated for the purpose, let them continue to use it; only we would especially note, that should an error ensue, it ought by all means to be attributed to the real cause, and to that only: for, as in all trigonometrical questions, the angle and side are always given to find the other parts of the triangle, consequently the sum of the one, and length of the other, are presupposed to have been correctly ascertained, previous to the commencement of any other operation.

Finally, for the learner's sake, we observe, that as the tables exhibit only the relative proportions to the radius of one fathom, or six feet, and are wrought out to five places of decimals to an inch, it becomes necessary that every one who would use this work successfully, should have some knowledge of decimated arithmetic; because he will have, in most cases, to multiply for the whole numbers, and take parts for the fraction of the fathom. For example: suppose the given side to be the hypothenuse, measuring 16 fathoms, 3 feet, and 6 inches, he will then have to take out the numbers opposite the given angle in the tables, and multiply them by 16, for the base and perpendicular respectively, then divide half the tabular measure for the 3 feet, and one sixth of the remainder for the 6 inches, and add them together for the sum of the required sides of the triangle. We have therefore introduced the following rules and examples in decimals, which are sufficient to enable any one, hitherto unacquainted with this branch of arithmetic, to use the tables with the greatest facility.

REDUCTION OF DECIMALS.

RULE.—Multiply the decimal by the number of parts in the next less denomination, and cut off as many places to the right hand as there are places in the given decimals.

EXAMPLE.

What is the value of ,75014 of a fathom?
6
4,50084
12
6,01008

ft. in.
Answer 4 . 6,01008

What is the value of ,93862 of a yard?
3
2,81586
12
9,79032

ft. in.
Answer 2 . 9,79032

What is the value of ,27734 of a foot?
12
3,32808

in.
Answer 3,32808

fath. ft. in.
Reduce 5 . 4 . 6,32 to feet, inches, and decimals.
6
in.
Answer 34 . 6,32

ADDITION OF DECIMALS.

RULE.—Place the numbers so that the decimal points may stand directly under each other, add up as in simple addition, and cut off for decimals, as many figures to the right as there are decimals in the greatest given number.

EXAMPLE.

What is the sum of 3,72 and 14,7368 and 146,2 and ,728 and 5,034?

3,72
14,7368
146,2
,728
5,034

170,4188

ft. in. ft. in.
What is the sum of 2 . 11,9942 and 1 . 4,09658?
1 . 4,09658

4 . 4,09078

Add together the following measures, viz.:

fath. ft. in. dec.
6 . 4 . 2,260
0 . 1 . 11,47298
19 . 0 . 3,087
64 . 5 . 9,9746
0 . 0 . 2,70643

91 . 0 . 5,50101

SUBTRACTION OF DECIMALS.

RULE—Arrange and cut off the decimals as in addition.

EXAMPLE.

	fath.	ft.	in.
From	4	2	9,7824
Take	2	4	8,91773
	1	4	0,86467

MULTIPLICATION OF DECIMALS.

RULE—Multiply as in whole numbers, and cut off as many figures from the product as there are decimals in the multiplier and multiplicand.

EXAMPLE.

	fath.	ft.	in.	
Multiply	2	4	7,92486	by 24
			6	
	16	3	11,54916	
			4	6 × 4 = 24
	66	3	10,19664	

	fath.	ft.	in.	
Multiply	9	3	1,4872	by 37
			6	
	57	0	8,9232	
			6	
	342	4	5,5392	
	9	3	1,4872	
	352	1	7,0264	

Here we multiply by 6 twice because 6 times 6 are 36, and add the given number which makes it equal to 37, or 6 × 6 + 1 = 37.

	ft.	in.	
Multiply	14	9,746	by 12
		12	
	177	8,952	

DIVISION OF DECIMALS.

RULE—Divide as in whole numbers, and cut off as many figures in the quotient as the decimal places in the dividend exceed those of the divisor.

EXAMPLE.

fath. ft. in.
Divide 2 . 4 . 3,7 by 6
6) 2 . 4 . 3,7
0 . 2 . 8,61

fath. ft. in.
7) 4 . 2 . 10,30994
0 . 3 . 10,04427

fath. ft. in.
8) 15 . 5 . 0,3316
1 . 5 . 10,5414

ALIQUOT PARTS OF A FATHOM.

TABLE.

Parts.		Feet.	Ins.
$\frac{1}{2}$	of a fathom is	3	0
$\frac{1}{3}$	ditto	2	0
$\frac{1}{4}$	ditto	1	6
$\frac{1}{6}$	ditto	1	0
$\frac{1}{8}$	ditto	0	9
$\frac{1}{9}$	ditto	0	8
$\frac{1}{12}$	ditto	0	6
$\frac{1}{16}$	ditto	0	4½
$\frac{1}{18}$	ditto	0	4
$\frac{1}{24}$	ditto	0	3

REMARKS.

IT has been observed that the radius in every case, is 6 feet or 1 fathom, consequently the number of fathoms in the given side, whether that side be hypothenuse, perpendicular, or base, will be the multiplier of the tabular numbers, and should there be a fraction in the multiplier, the multiplicand must be divided by that fraction agreeably with the rule of practice. The table of aliquot parts of a fathom, in the adjoining page, will be found useful in facilitating this part of the process.

In some of the following examples the product has been obtained in fathoms and parts, but we would recommend the learner to carry on the work in *feet*, (except in cases where the answer is required in fathoms) as he will find it more simple and expeditious; we speak of the *multiplicand* or number *multiplied*; the *multiplier* must invariably be fathoms, and should the given side be nominated in feet, it must be divided by 6, to bring it into fathoms, before the operation is begun by the foregoing cases.

It may be further noticed that when any of the given sides in the tables amount to 6 feet, they are expressed in fathoms, &c. but when ever it may be required to produce the answer in feet, &c. the numbers should be reduced to that measure before they are multiplied, and this can be done by mere inspection, viz.

		fath.	ft.	in.			ft.	in.
Table 2nd,	Base	1	1	8,1560	state	Base	7	8,1560
∠ 52°	Hyp.	1	3	9,6053		Hyp.	9	9,6053

PRELIMINARY CHAPTER

TO THE PRACTICAL DIALLING EXAMPLES.

It must have been matter of regret to every reflecting, well-informed, and interested person, that (previous to the present work) nothing has ever been published with a design to assist the British miner in his subterraneous operations, and while the press has teemed with publications, distinctly and exclusively adapted to benefit the navigator, the architect, the sculptor, the surveyor, and even the mechanic and artisan, not a single effort has ever been made to extricate the miner from the disadvantages under which he has ever laboured, (solely for the want of a plain, concise, technical, and scientific treatise on dialling, accompanied with appropriate tables), although his profession yields to none in importance and utility; in fact it may be said, in a certain sense, to be the parent of every art and science in the world; the use of metallic substances, in some shape or other, being indispensable in every one of them: nevertheless this highly essential art has hitherto been totally disregarded by all classes of mathematicians, and while the famous invention of logarithms has caused the science of trigonometry to soar to the very skies, and traverse old ocean's vast and unfathomable expanse, the unsupported miner has been left to struggle under the greatest disadvantages, with nearly as little obligation to geometrical science, as his antediluvian progenitors; and although he has done every thing that deep thought, strong natural understanding, unwearied perseverance, and inventive genius (unassisted by trigonometrical demonstration) could possibly accomplish, yet for the want of mathematical light, his exertions have been ineffectual and insufficient to disentangle him from the difficulties with which he has been encircled; hence his avocation has, in general, been replete with toil, anxiety, apprehension, dissatisfaction, and disappointment.

How far the present work is adapted to answer the great end in contemplation, must be left for the judgment of the mining world to decide; and we doubt not but the defects (real or imaginary) which may be considered to exist in the application, will be passed over and excused by every liberal man, on the grounds already stated in the preface; having an unshaken confidence that the fundamentals of the work, comprised in the trigonometrical tables, will be found plain, true, and unexceptionable.

DEFINITION OF RIGHT-ANGLED TRIANGLES.

In order to use the following tables with due effect, there is no necessity that the reader should understand any thing of the science of trigonometry, that part of the work having been accomplished already to his hand, so that, by the help of a few of the common rules of arithmetic, he may obtain, with the greatest ease and certainty, every thing required to be known in the geometrical part of mining.

Previous to an elucidation of the simple method of working by the tables, it may be satisfactory to introduce the operation by a few preliminary observations and extracts on the nature and properties of right-angled triangles.

Plane trigonometry is the art of measuring the sides and angles of triangles described on a plane surface, or of such triangles as are composed of straight lines.

The theory of triangles is the very foundation of all geometrical knowledge, for all straight-lined figures may be reduced to triangles. The angles of a triangle determine only its relative species, and are measured in degrees, minutes, and seconds; but the sides determine its absolute magnitude, and may be expressed in fathoms, yards, feet, or any other lineal measure.

THEOREMS.

A right-angled triangle (the only kind generally necessary to be treated of for mining purposes) is that which has one right angle in it; the longest side, or that opposite to the right angle, is called the hypothenuse, the other two are called the legs or sides, or the base and perpendicular: or, by Euclid's definition, "In a right-angled triangle, the side opposite to the right angle is called the HYPOTHENUSE, and of the other sides, that upon which the figure is supposed to stand is called the BASE, and the remaining side the PERPENDICULAR.

The three angles of every triangle are together equal to two right angles, or 180 degrees.

The greater side of every triangle has the greater angle opposite to it.

The squares of two sides of a triangle are together double of the square of half the base, and of the square of a straight line drawn from the vertex to bisect the base.

The sum of the three angles of every plane triangle being equal to half a circle, or 180 degrees, it therefore follows that if either acute angle, in such triangle, be taken from 90°, the remainder will be the other acute angle, or the complement.

The supplement of any angle is what that angle wants of 180°, hence the supplement of any one angle is always equal to the sum of the other two.

A few other properties of right-angled triangles may be worthy of notice, viz.: when the angle opposite the base is 30° the hypothenuse is exactly double the length of the base.

When the angles are 45° the base and perpendicular are equal.

When the angle opposite the base is 60° the hypothenuse is double the length of the perpendicular.

APPLICATION.

To shew how a knowledge of the foregoing theorems may be rendered useful in mining practices, suppose in the triangle A B C, on page 1, the base B A represented a drift or cross-cut, and the side A C a lode, making an angle with the base of 66° 30′; consequently the angle A must be 23° 30′, because it requires that number of degrees to constitute a right angle, the complement of the angle A, or 180°, the supplement of the triangle A B C.

Again, suppose the angle C of the diagonal shaft C A, page 2, was found to be 39° 30′, then the opposite angle A must contain 50° 30′.

We now approach towards the actual use of the tables, and have succeeded, we hope, in clearing all impediments out of the learner's way, so that he will find no difficulty in readily applying the numbers to dialling operations. We have previously set a few examples of the mere act of taking out the primes, and have studiously endeavoured to render every thing so perspicuous and comprehensible as the nature of the work would possibly admit. But should any one have gone thus far and still find an obscurity hang over him, so that he cannot penetrate into the nature of the subject as he would wish, or as he may have expected, yet let him not be discouraged; this will always be the case with every one who calculates on fully comprehending any thing connected with the mathematics by definition or description only. Let him steadily, attentively, and perseveringly proceed with the examples, and if he is properly interested in the matter, he will soon find the subject open with perspicuity and demonstration on his mind, and convey to him the incontrovertible assurance of the truth of the calculations, as well as the correctness of his own views, ideas, or conceptions of the subject.

TABLE 1.—EXAMPLE.

When the angle is 9° and the hypothenuse 1 fathom, what is the length of the other two sides of the triangle respectively?

(page 33)

in. ft. in.
Answer, Base 11,26328 Perp. 5 . 11,11356

EXAMPLE.

When the angle is 48° 15′, or 48¼ degrees,* and the hypothenuse 1 fathom, what are the lengths of the other sides?

(page 37)

ft. in. ft. in.
Answer Base 4 . 5,71613 Perp. 3 . 11,94348

TABLE 2.—EXAMPLE.

When the angle is 35° 45′, or 35¾ degrees, and the perpendicular 1 fathom, what is the length of the hypothenuse and base respectively.

(page 42)

ft. in. fath. ft. in.
Answer Base 4 . 3,8326 Hyp. 1 . 1 . 4,7165

EXAMPLE.

Given the angle 59° 30′, Perpendicular 1 fathom, the other sides are required.

(page 45)

fath. ft. in. fath. ft. in.
Answer Base 1 . 4 . 2,2317 Hyp. 1 . 5 . 9,8612

---

* In this example as the angle exceeds 45° it will be found standing on the right hand side of the page, (as already explained) and the denomination of the required sides will be found at the bottom: a little attention to this order will prevent the mistake, which may otherwise take place, by an inversion of the base and perpendicular.

TABLE 3.—EXAMPLE.

Given the angle 5°, base 1 fathom, the hypothenuse and perpendicular are required.

(page 47)

	fath.	ft.	in.		fath.	ft.	in.
Answer Hyp.	11 .	2 .	10,10734	Perp.	11 .	2 .	6,96374

EXAMPLE.

Given the angle 30°, base 1 fathom, the other sides are required.

(page 48)

	fath.	ft.	in.		fath.	ft.	in.
Answer Hyp.	2 .	0 .	0	Perp.	1 .	4 .	4,70766

NOTE.

The foregoing examples serve only to exemplify the manner ot taking out the primes from the tables, and as the given side is exactly one fathom, of course the tables give a direct answer. In the following examples the mode of taking out the tabular numbers is precisely as the foregoing, but the number of fathoms contained in the length of the given side, will be the multiplier of the other sides of the triangle.

PLANE TRIGONOMETRY,

BY THE TABLES.

CASE. I.

WHEN THE HYPOTHENUSE IS GIVEN.

RULE—Look in the first table, and against the given angle stands the base and perpendicular, answering to one fathom of the hypothenuse; take out these numbers and multiply them respectively by the length of the hypothenuse.

EXAMPLE.

Given the angle 23° 30′, and hypothenuse 12 fathoms; the base and perpendicular are required.

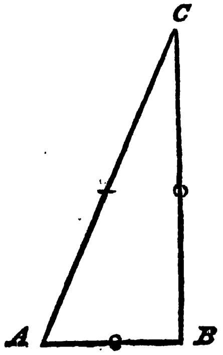
OPERATION.

BASE.	PERPENDICULAR.
Feet 2 . 4,70993	Feet 5 . 6,02833
12	12
28 . 8,51916	66 . 0,33996

PROCESS.

Draw the line A B of any length, make the angle C = 23° 30′ by a scale of chords, or with a protractor; draw the hypothenuse A C = 72 feet from a scale of equal parts. From C let fall the perpendicular C B; then A B C is the triangle required. A B measured by the same scale of equal parts will be 28 feet 8½ inches, and B C will be 66 feet.

Scale—40 *feet to an inch.*



CASE 2.

WHEN THE PERPENDICULAR IS GIVEN.

RULE—Look in the second table, and opposite the given angle will be found the base and hypothenuse corresponding to one fathom of the perpendicular, multiply these numbers separately by the length of the perpendicular.

EXAMPLE.

Given the angle 39° 30′, and perpendicular 9 fathoms, 3 feet; the hypothenuse and base are required.

OPERATION.

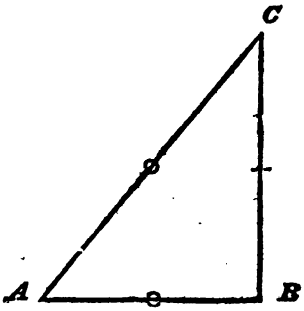
		fath.	ft.	in.
3	½	0	4	11,3522
				9
		7	2	6,1698
		0	2	5,6761
Base		7	4	11,8459[*]

		fath.	ft.	in.
3	½	1	1	9,3096
				9
		11	3	11,7864
		0	3	10,6548
Hyp.		12	1	10,4412

BY CONSTRUCTION.

PROCESS.

Draw the line A B of a sufficient length, at any point B erect the perpendicular B C which make equal to 57 feet by a scale of equal parts. At C make the angle=39° 30′ the complement of A. From C draw the hypothenuse, and it will cut the base A B in the point A; then will A B measure 47 feet, and A C 73 feet 10 inches.



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[*] It has been before observed that it would be better to bring the answer out in feet than in fathoms, as in the last case.

CASE 3.

WHEN THE BASE IS GIVEN.

RULE—Look in the third table, and opposite the given angle (as in the former cases) the corresponding numbers to one fathom of base will be seen, which being multiplied by the given length of the base produces the hypothenuse and perpendicular.

EXAMPLE.

Given the angle 20 degrees, and base 28 feet 9 inches; the hypothenuse and perpendicular are required.

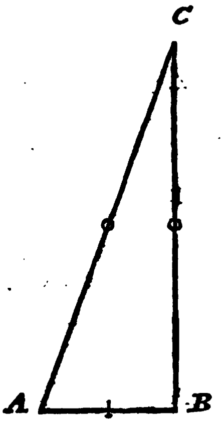
		ft.	in.
∠20°	$\frac{1}{2}$	17 .	6,51392*
			4
		70 .	2,05568
	$\frac{1}{3}$	8 .	9,25696
	$\frac{1}{8}$	2 .	11,08565
		2 .	2,31424
Hyp.		84 .	0,71253

		ft.	in.
	$\frac{1}{2}$	16 .	5,81837*
			4
		65 .	11,27348
	$\frac{1}{3}$	8 .	2,90918
	$\frac{1}{8}$	2 .	8,96972
		2 .	0,72729
Perp.		78 .	11,87967

BY CONSTRUCTION.

PROCESS.

Draw the base A B which make =28 feet 9 inches, from a scale of equal parts, at B erect the perpendicular B C, make the angle A = 70° and draw the hypothenuse A C to cut the perpendicular B C in the point C, then will A C measure 84 feet, and B C 78 feet, 11½ inches.



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* These numbers stand in the tables in fathoms, &c. the hypothenuse will be found 2 fathoms, 5 feet, 6 inches, &c. and the perpendicular 2 fathoms, 4 feet, 5 inches, &c.

APPLICATION OF THE TABLES
TO
DIAGONAL SHAFTS.

REMARKS.

As in the foregoing cases each side of the triangle is distinctly made radius, it follows that every problem in oblique dialling, &c. can be solved by one or the other of these cases; because in every instance, a side and the angles are always given.

GENERAL RULE.

When the hypothenuse is given, work by case the first.
When the perpendicular is given, work by case the second.
When the base is given, work by case the third.

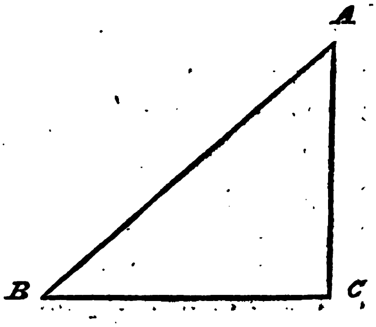
EXAMPLE.

A diagonal shaft A B was found to measure 84 feet,* and the angle of declination observed to be 48 degrees; required the base B C, and perpendicular A C.

BY CASE THE FIRST.

	ft.	in.
∠ 48°	4 .	5,50643
		7
	31 .	2,54501
		2
Base	62 .	5,09002

	ft.	in.
	4 .	0,17740
		7
	28 .	1,24180
		2
Perp.	56 .	2,48360



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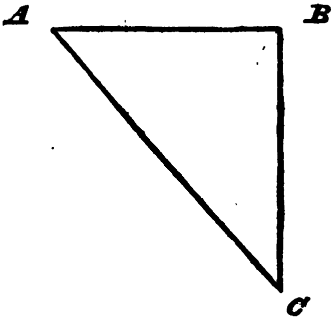
* When the given line is denominated in feet, it must be brought into fathoms by dividing it by 6, (the number of feet in a fathom); thus in the above example the shaft being 84 feet, is 14 fathoms, and therefore the numbers are multiplied by 7 and 2, which are equal to 14.

EXAMPLE 2.

A perpendicular shaft B C, measuring 57 feet, was found to intersect an underlaying shaft A C, whose angle of acclivity was observed to be 50° 30′; required the length of the underlaying shaft A C, and the distance from the perpendicular at the surface A B.

BY CASE THE SECOND.

			ft	in.
∠50° 30′ Comp. 39° 30′	Base	½	4 .	11,3522
				9
			44 .	6,1698
			2 .	5,6761
A B			46 .	11,8459



		ft.	in.
Hyp.	½	7 .	9,3096
			9
		69 .	11,7864
		3 .	10,6548
A C		73 .	10,4412

NOTE.

In the above example the angle having again been taken with the horizon the operative angle will be 39° 30′, because 50° 30′ — 90° = 39° 30′. We may also observe that the length of the shaft being 57 feet, the multiplier is 9½, or 9 fathoms, 3 feet.

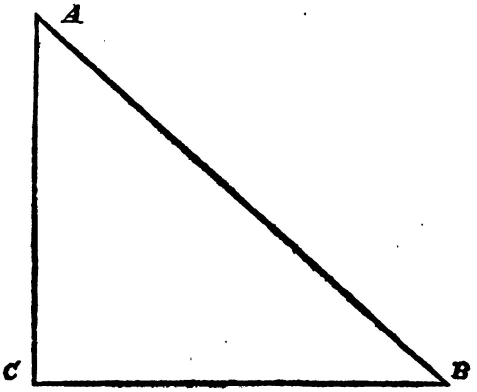
EXAMPLE 3.

A horizontal cross-cut B C from the foot of a diagonal B A to a perpendicular shaft C A was found to measure 224 feet, 8 inches, and the angle of acclivity (taken at B the foot of the shaft) 40 degrees; I require the respective lengths of the hypothenuse A B and perpendicular A C.

BY CASE THE THIRD.

		ft.	in.
∠40° Comp. 50°	$\frac{1}{3}$	7 .	9,98932*
			12
		93 .	11,87184
			3
		281 .	11,61552
		7 .	9,98932
	$\frac{1}{3}$	2 .	7,32977
		0 .	10,44325
A B		293 .	3,37786

		ft.	in.
	$\frac{1}{3}$	5 .	0,41517
			12
		60 .	4,98204
			3
		181 .	2,94612
		5 .	0,41517
	$\frac{1}{3}$	1 .	8,13839
		0 .	6,71279
A C		188 .	6,21247



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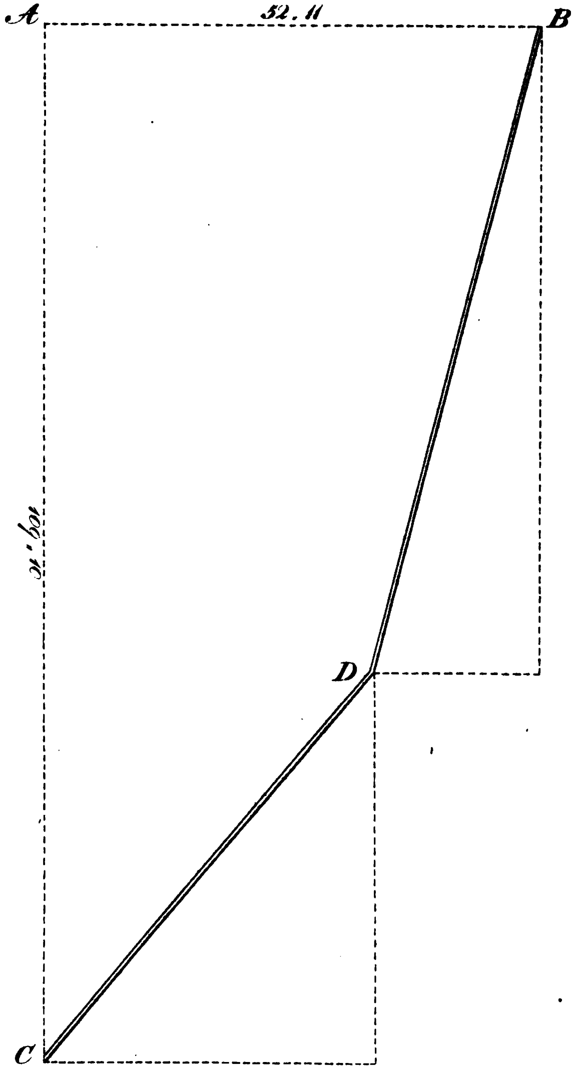
fath. ft. in.

* It will be observed that this number stands in the table 1 . 1 . 9,98932, and the angle having been taken at the foot of the shaft, the complement of that angle (i. e. what it wants of 90°) must be used, therefore the above tabular numbers will be found in the column opposite 50°, being the complement of 40°.

SCALE

Twenty Feet to an Inch



EXAMPLE 4.

When a lode has changed its underlay.

RULE—Take out the numbers opposite the given angles and work them by the former cases, then add their sums together respectively for the answer.

PROBLEM.

In dialling a shaft sunk on a lode, it was found that the first draft B D measured 71 feet, on an angle of 14° 45′, but from that depth to the foot of the shaft C the angle proved to be 40° 15′, and the length D C 54 feet: required the distance from the brace of the diagonal B, where a perpendicular shaft ought to be sunk, in order to come down exactly at the foot of the underlay; also the depth of the perpendicular A C.

OPERATION.

BASE.

			fath.	ft.	in.
∠14° 45′	1	$\frac{1}{6}$	0	1	6,33134
					12
			3	0	3,97608
			0	0	3,05522
			3	0	0,92086

PERPENDICULAR.

		fath.	ft.	in.
1	$\frac{1}{6}$	0	5	9,6273
				12
		11	3	7,5276
		0	0	11,6045
		11	2	7,9231

BASE.

	fath.	ft.	in.
∠40° 15′=	0	3	10,52093
			9
	5	4	10,68837

PERPENDICULAR.

fath.	ft.	in.
0	4	6,95274
		9
6	5	2,57466

SUMMARY OF BASES.

	fath.	ft.	in.
	3	0	0,92086
	5	4	10,68837
	8	4	11,60923
	6		
A B	52 feet		11 ins.

SUMMARY OF PERPENDICULARS.

	fath.	ft.	in.
	11	2	7,9231
	6	5	2,57466
	18	1	10,49776
	6		
A C	109 feet		10 ins.

EXAMPLE 5.

When a lode has changed or reversed its underlay from north to south, or east to west.

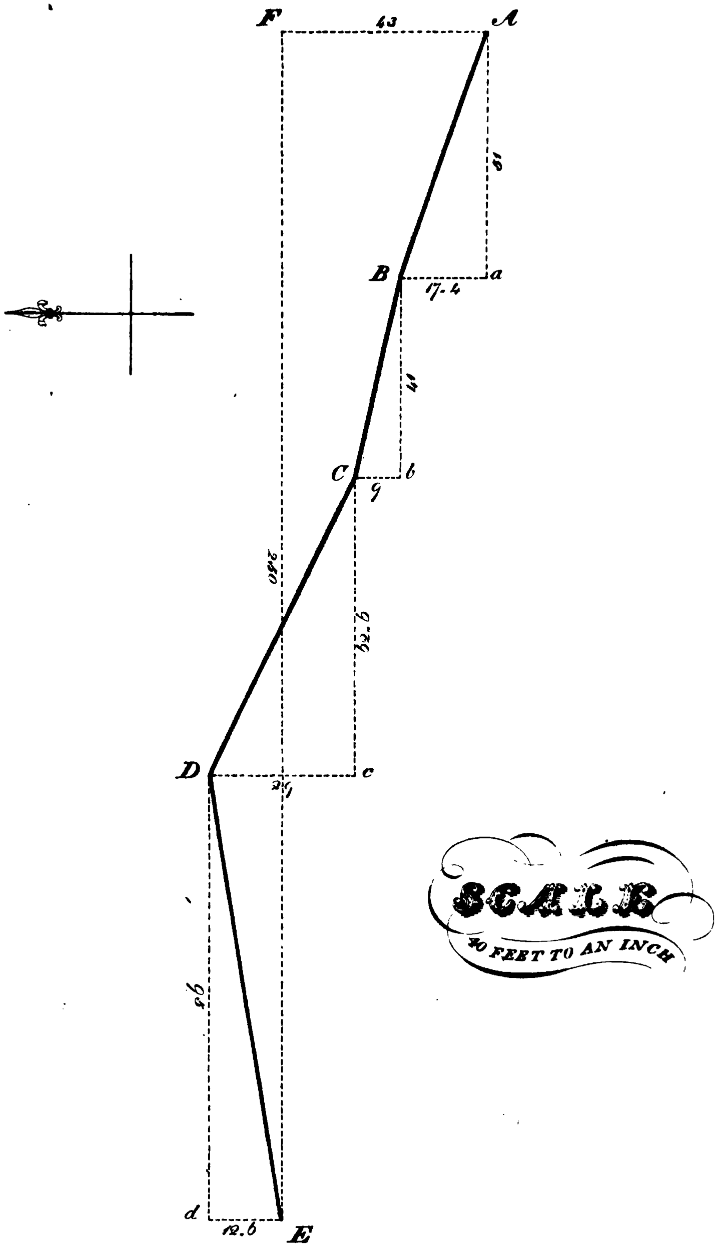
RULE—Add all the perpendiculars together, as in the last problem, but subtract the bases, made by the reverse or contrary shafts, one from the other, the remainder will be the true length of the base.

PROBLEM.

A diagonal shaft was found to incline and measure as follows, viz.

A B	54 feet	18°	45′
B C	42 do.	12°	15′
C D	69 do.	25°	0′

throughout the above drafts, the declination or underlay bore northerly, but from that depth D it made an angle of 7° 30′ in a southerly direction, and this last draft D E measured 96 feet. It is required to know the perpendiculars and bases of all the foregoing sides respectively and collectively.


F
43
A
61
B
a
17.4
41
C
b
9
250
62.6
D
c
29
95
d
12.6
E
SCALE
40 FEET TO AN INCH

VIII

OPERATION.

	BASES NORTHERLY.				PERPENDICULARS.		
	fath.	ft.	in.		fath.	ft.	in.
∠ 18° 45′=	0	1	11,14364		0	5	8,17897
			9				9
Ba	2	5	4,29276	Aa	8	3	1,61073
∠ 12° 15′=	0	1	3,27680		0	5	10,36062
			7				7
Cb	1	2	10,93760	Bb	6	5	0,52434
∠ 25° 0′=	0	2	6,42852		0	5	5,25416
			11				11
	4	3	10,71372		9	5	9,79576
	0	1	3,21426		0	2	8,62708
Dc	4	5	1,92798	Cc	10	2	6,42284

	BASE SOUTHERLY.						
	fath.	ft.	in.		fath.	ft.	in.
∠ 7° 30′=	0	0	9,39789		0	5	11,38403
			8				8
	1	0	3,18312		7	5	7,07224
			2				2
Ed	2	0	6,36624	Dd	15	5	2,14448

SUMMARY.

	BASES.				PERPENDICULARS.		
	fath.	ft.	in.		fath.	ft.	in.
	2	5	4,29276		8	3	1,61073
	1	2	10,93760		6	5	0,52434
	4	5	1,92798		10	2	6,42284
North	9	1	5,15834		15	5	2,14448
South	2	0	6,36624		41	3	10,70239
	7	0	10,79210		6		
	6						
F A	42 feet		10 ins.	F E	249 feet.		10 ins.

EXAMPLE 6.

When a shaft has been sunk in error,* or not exactly at right angles with the lode.

RULE I.

Work for the base and perpendicular as before, by case 1, then find the deviation by the following

RULE II.

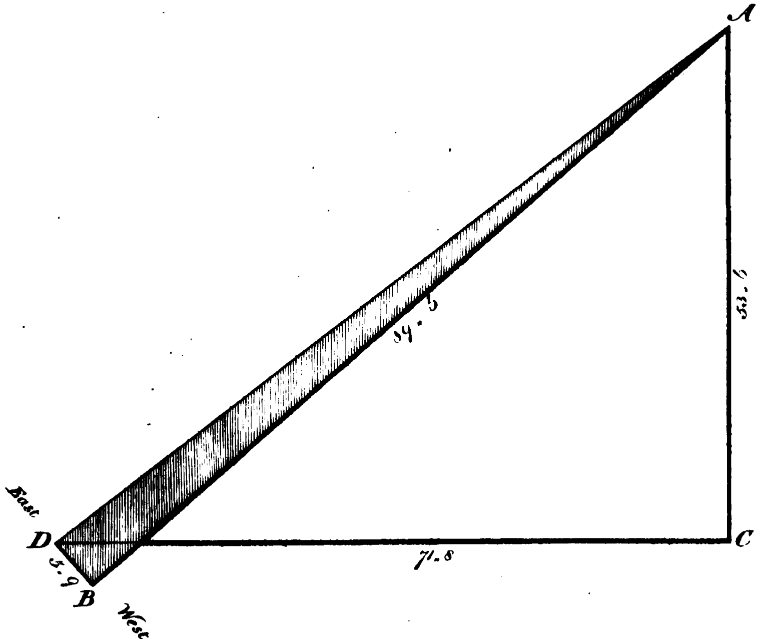
Take out the base from the second table, standing opposite the angle of error, and multiply it by the length of the shaft.

---

* Underlaying shafts are always intended to be sunk at right angles with the lode; that is, if the lode runs east and west, the horizontal bearing of the shaft will be either north or south, as the lode may happen to underlie. But it is sometimes the case, that through inattention of workmen or other causes, the shaft has declined from its true course and inclined toward the right or left, and as this is neither a trivial or uncommon occurrence, and admits not of development by the ordinary mode of dialling, we have here introduced a rule which will hold good in all cases of the kind.

Scale

20 FEET TO AN INCH



Banks

X

PROBLEM.

An oblique shaft A B was found to measure 89 feet 6 inches, on an angle of 53° 15′, and it was also observed that the shaft had declined 3° 45′ west from the intended right angle of the east and west lode: required the base C D and perpendicular C A, and how far the shaft has departed from its true course A D.

OPERATION.

			ft.	in.
∠ 53° 15′	3	½	4	9,69027
				7
			33	7,83189
				2
			67	3,66378
			2	4,84513
	2	⅓	1	7,23009
	0.6	¼	0	4,80752
		Base	71	8,54652

		ft.	in.
3	½	3	7,07937
			7
		25	1,55559
			2
		50	3,11118
		1	9,63968
2	⅓	1	2,35979
0.6	¼	0	3,58994
	Perp.	53	6,60059

THEN FOR THE DEVIATION.

		ft.	in.
Table 2nd.—∠ 3° 45′ Base	½	0	4,7189
			7
		2	9,0323
			2
		5	6,0646
		0	2,3594
	⅓	0	0,78
	¼	0	0,19
		5	9,3940

Thus it is clear that if the above shaft was sunk on an east and west lode and the angle of error inclined westerly, that the foot of the shaft B would be 5 feet, 9¼ inches, in that direction beyond its designed course A D.

EXAMPLE 7.

To find the perpendicular depth of the junction of lodes.

CASE 1.

When two lodes underlay in the same direction.

RULE—Subtract the tabular number of the base of the lesser angle from the greater, then by direct proportion, say,

As this difference
Is to one fathom perpendicular,
So is the distance of the lodes at surface
To the junction of the lodes.

PROBLEM.

Two lodes were discovered at the surface, 12 fathoms apart from C to D, both underlaying north. The southernmost lode D B made an angle of 38° 15′: the other C B 23°. Required the perpendicular depth A B where these lodes will unite, supposing they both regularly continue their respective angles of declination.

OPERATION.

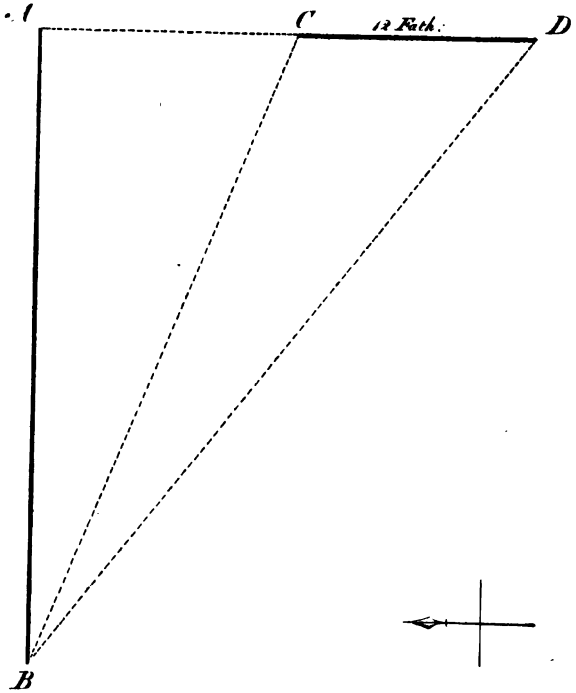
ft. in.
From ∠ 38° 15′ = 4 . 8,7602
Take ∠ 23° 0′ = 2 . 6,5622
2 . 2,1980

ft. in. fath. fath.
Then, As 2 . 2,198 : 1 : : 12
12 6
26,198 72
12
26,198) 864,000 (32,9
78594 6
78060 5,4
52396 12
256640 4,8
235782
20858

fath. ft. in
Answer 32 . 5 . 4 A B

SCALE

40 FATHOMS TO AN INCH



DIAGONAL LODES.

If it is required to find the respective lengths of the lodes C B and D B, and the horizontal line D A, work by case the second, where the perpendicular is given.

TO FIND D B.

		fath.	ft.	in.
∠ 38° 15′	$\frac{1}{9}$	1 .	1 .	7,6831
				11
		14 .	0 .	0,5141
				3
		42 .	0 .	1,5423
		0 .	0 .	10,1870
D B		41 .	5 .	3,3553

Here we multiply by 33 and subtract from the product what the hypothenuse is minus of that measure, which being eight inches, is one-ninth of a fathom. This is the shortest method.

TO FIND C B AND D A, OR C A.

		BASE.					HYPOTHENUSE.		
		fath.	ft.	in.			fath.	ft.	in.
∠ 23° 0′	$\frac{1}{9}$	0 .	2 .	6,5622		$\frac{1}{9}$	1 .	0 .	6,2179
				11					11
		4 .	4 .	0,1842			11 .	5 .	8,3969
				3					3
		14 .	0 .	0,5526			35 .	5 .	1,1907
		0 .	0 .	3,3964			0 .	0 .	8,6908
C A		13 .	5 .	9,1580	C B		35 .	4 .	4,4999

Then C A + C D = D A, or C A added to C D gives the line D A, 25 fathoms, 5 feet, 9 inches, &c.

EXAMPLE 8.

To find the perpendicular depth of the junction of lodes.

CASE 2.

When two lodes, by their underlay, incline indirectly towards each other.

RULE—Add the tabular bases together, then find the depth by direct proportion as in the last example.

PROBLEM.

Two lodes were observed 36 fathoms apart at the surface from A to C, the northernmost lode A underlaying south 18° 15′, and the southernmost lode C underlaying north 31° 45′: required the depth B D at which these lodes will intersect each other.

OPERATION.

		ft.	in.
To ∠ 18° 15′	=	1 .	11,6220
Add ∠ 31° 45′	=	3 .	8,5550
		5 .	8,177

	ft. in.		fath.		fath.
Then, As	5 . 8,177	:	1	: :	36
	12				6
	68,177				216
					12

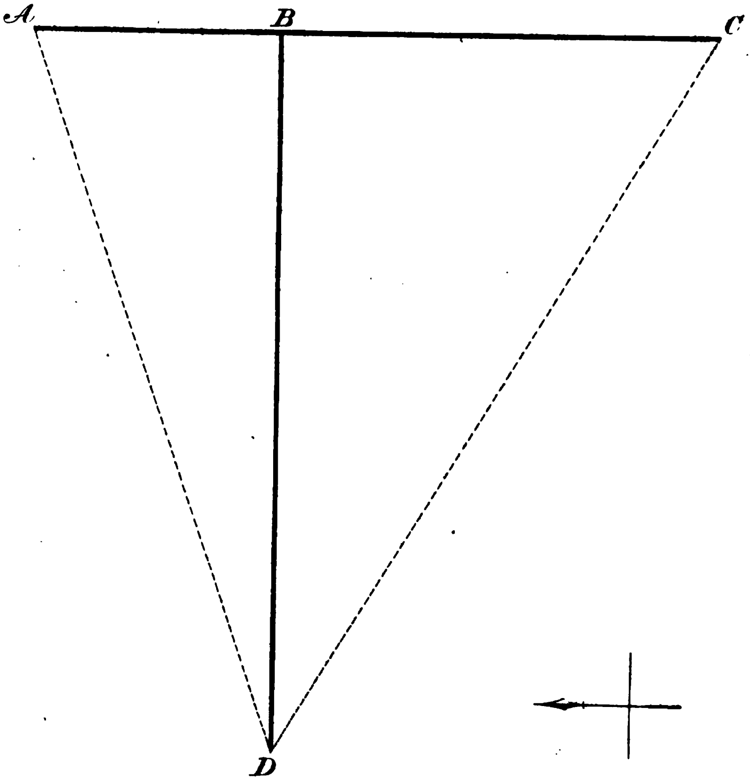
68,177) 2592,0000 (38,0
204531
546690
545416
12740

Answer 38 fathoms.

SCALE

10

F. & THOMSON LITH



XIV

If required to find the length of the lodes A D and C D and the distance of the shaft B from the lodes C and A at the surface, work by case the 2nd, thus:

TO FIND A B AND A D.

	BASE.				HYPOTHENUSE.		
	fath.	ft.	in.		fath.	ft.	in.
∠ 18° 15′=	0	1	11,622		1	0	3,8135
			6				6
	1	5	9,732		6	1	10,8810
			6				6
	11	4	10,392		37	5	5,2860
	0	3	11,244		2	0	7,6270
A B	12	2	9,636	A D	40	0	0,9130

TO FIND B C AND C D.

	BASE.				HYPOTHENUSE.		
	fath.	ft.	in.		fath.	ft.	in.
∠ 31° 45′=	0	3	8,555		1	1	0,7008
			6				6
	3	4	3,330		7	0	4,2048
			6				6
	22	1	7,980		42	2	1,2288
	1	1	8,110		2	2	1,4016
B C †	23	3	1,090	C D	44	4	2,6304

---

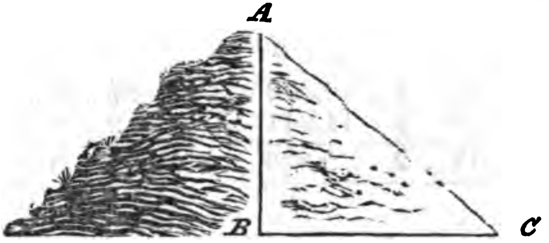
† It may be observed that A B and B C added together do not make 36 fathoms, by something more than an inch: now this does not happen through any defect in the tables, but because the perpendicular has not been worked out—for if the remainder (12740) was prosecuted, the perpendicular would prove to be $\overset{\text{fath.}}{38}$. $\overset{\text{ft.}}{0}$. $\overset{\text{in.}}{1,3392}$, instead of 38 fathoms, which addition to multipliers would make up the exact deficiency.

PERPENDICULAR SHAFTS

AND

LEVELS.

RULE—When the angle of acclivity is given, take the complement (or what it wants of 90°) for the operative angle; in every other particular, work by the former cases.

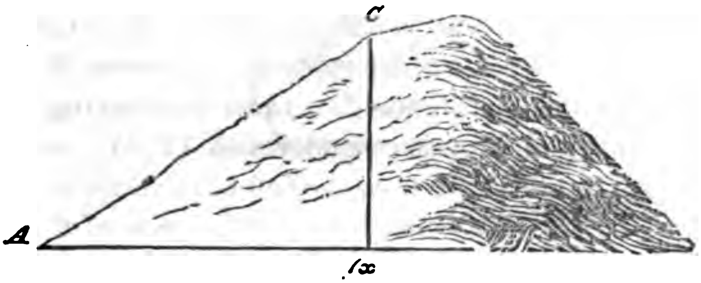


EXAMPLE 1.

A perpendicular shaft having been sunk from the top of a hill at A from whence the slope to C measured 330 feet: It is required to know the length an adit must be driven from the base of the hill at C to intersect the shaft at B, and what will be the depth of the shaft at that intersection, the angle of acclivity at C being 41 degrees.

BY CASE THE SECOND.

	PERPENDICULAR.		BASE.	
	ft.	in.	ft.	in.
Comp. of 41° is 49°	3	11,23625	4	6,33909
		9		9
	35	5,12625	40	9,05181
		6		6
	212	6,75750	244	6,31086
	3	11,23625	4	6,33909
	216	5,99375	249	0,64995



EXAMPLE 2.

An adit having been driven 75 fathoms from A to B, required to know how far up the hill from A I ought to measure in order that a perpendicular may be sunk to intersect the adit at x, 58 fathoms from the tail at A; also the depth of the shaft C x, the angle of acclivity from A towards C being 33 degrees. Or thus:—Given the base 58 fathoms; angle of acclivity 33°, of which the complement or angle of declivity is 57°; required the hypothenuse and perpendicular.

BY CASE THE THIRD.

	HYPOTHENUSE.			PERPENDICULAR.	
	ft.	in.		ft.	in.
Comp. ∠ 33° is 57° =	7	1,85016		3	10,75735
		8			8
	57	2,80128		31	2,05880
		7			7
	400	7,60896		218	2,41160
	14	3,70032		7	9,51470
A C	414	11,30928	C x	225	11,92630

EXAMPLE 3.

From the foot of a perpendicular shaft A B, 70 fathoms in depth, a cross-cut was driven south 14 fathoms 3 feet in length (C,) where a lode was discovered underlaying north, and the angle of ascension or elevation 72° 45′: required the length of this lode from the end of the drift C to the surface D; also the distance from the brace of the perpendicular shaft A to the back of the lode at grass (D,) supposing the lode to have a regular underlay.

BY CASE THE SECOND.

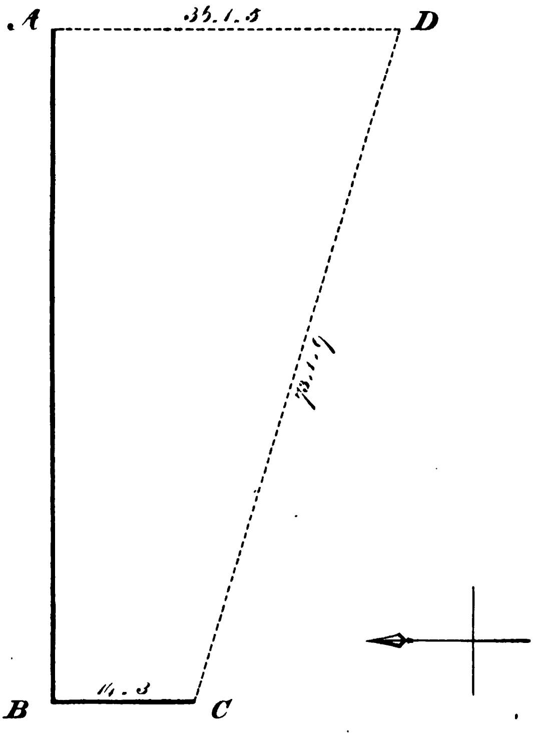
	BASE.			HYPOTHENUSE.		
	fath.	ft.	in.	fath.	ft.	in.
Comp. of ∠ 72° 45′ is 17° 15′	0	1	10,3560	1	0	3,3911
			7			7
	2	1	0,4920	7	1	11,7377
			10			10
	21	4	4,9200	73	1	9,3770
Add length of drift	14	3	0			
	36	1	4,92			

ANSWER.

	fath.	ft.	in.
Length of lode	73	1	9¼
Distance from shaft at the surface	36	1	5

Scale

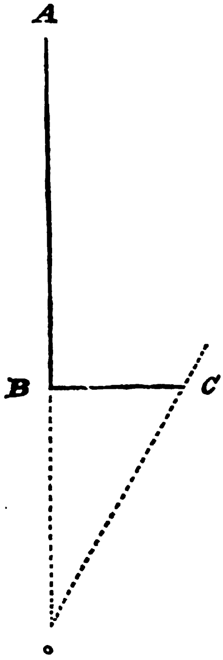
20 FATHOMS TO AN INCH



XVIII

EXAMPLE 4.

From the depth of 36 fathoms 4 feet, in an engine shaft A B, a cross-cut was driven which pierced a lode C, 14 fathoms 2 feet, from B. The lode was found to make an angle of 30 degrees, inclining towards the shaft. Required the depth at which the shaft will intersect the lode, and the length of the lode from C to the point of intersection o.



BY CASE THE THIRD.

	HYPOTHENUSE.			PERPENDICULAR.		
	fath.	ft.	in.	fath.	ft.	in.
∠ 30°	⅓) 2	0	0	⅓) 1	4	4,70766
			2			2
	4	0	0	3	2	9,41532
			7			7
	28	0	0	24	1	5,90724
	0	4	0	0	3	5,569
	28	4	0	24	4	11,47624

ANSWER.

	fath.	ft.	in.
Depth from A to B	36	4	0
Depth from B to o	24	4	11,47624
Extreme depth	61	2	11,47624

	fath.	ft.
Length from C to o	28	4

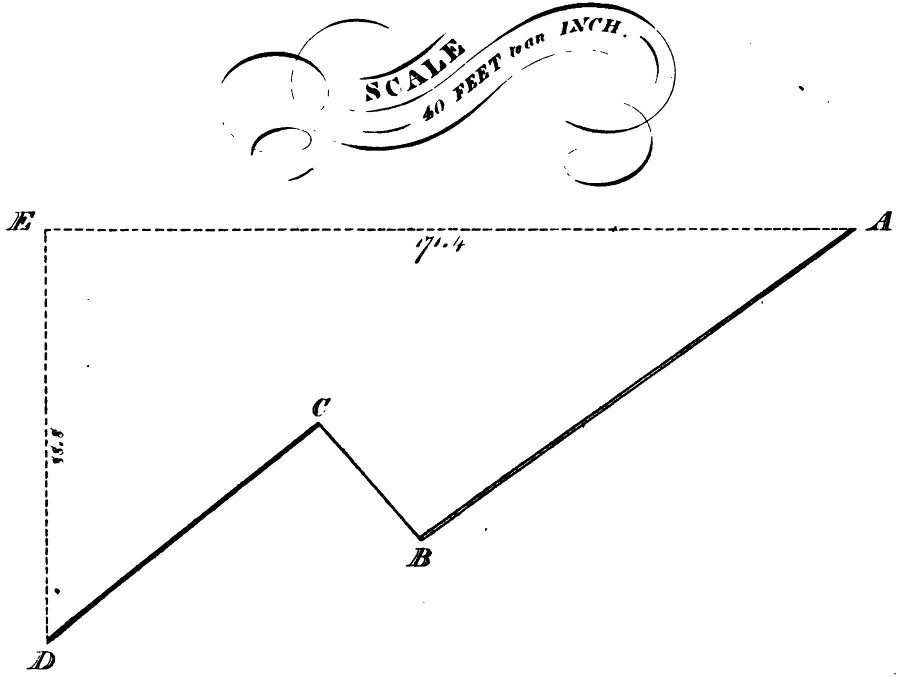
SLIDES.

When a lode has been thrown up by a slide, to find the base and perpendicular.

RULE—Add the bases made by the segments of the lode together for the horizontal, and subtract the perpendicular made by the ascension of the slide from the sum of the others for the perpendicular.

EXAMPLE.

A shaft having been sunk on a lode 114 feet from A to B, on an angle of 54° 30′, at this place the lode was separated and thrown up by a slide, from B to C, 32 feet, the angle of elevation at B being 47°: at C the lode was again cut and prosecuted on an angle of 51°, from C to D, 73 feet. Required to know the length from A to E at surface, where a perpendicular shaft should be put down, that would intercept the lode at the foot of the diagonal C D; also the depth of the shaft E D.



XX

THE FOREGOING EXAMPLE BY THE TABLES.

		BASE.			PERPENDICULAR.		
		ft.	in.		ft.	in.	
∠ A 54° 30′ =		4	10,61632		3	5,81062	
			6			6	
		29	3,69792		20	10,86372	(Multiplier 19 faths.)
			3			3	
		87	11,09376		62	8,59116	
		4	10,61632		3	5,81062	
		92	9,71008		66	2,40178	

		ft.	in.		ft.	in.	
∠ B 47° 0′ Comp. 43° 0′ =	⅓	4	1,10388	⅓	4	4,65747	
			5			5	
		20	5,51940		21	11,28735	(Multiplier 5 fath 2 ft.)
		1	4,36796		1	5,552	
		21	9,88736		23	4,83935	

		ft.	in.		ft.	in.	
∠ C 51° 0′	$\frac{1}{6}$	4	7,95451	$\frac{1}{6}$	3	9,81107	
			12			12	
		55	11,45412		45	3,73284	(Multiplier 12 fa. 1 ft.)
		0	9,32575		0	7,55184	
		56	8,77987		45	11,28468	

SUMMARY.

	BASES.			PERPENDICULARS.	
	ft.	in.		ft.	in.
	92	9,71008	∠ A =	66	2,40178
	21	9,88736	∠ C =	45	11,28468
	56	8,77987		112	1,68646
			∠ B =	28	4,83935
Answer E A =	171	4,37731	D E =	88	8,84711

NOTE.

Perpendiculars to strike B or C and their respective horizontal distances from A, are shewn by the sums of the first and second operation in the above calculations.

When a lode has been thrown down by a slide.

RULE—Add the perpendiculars together for the depth, and subtract the base of the slide from the bases of the segments of the lode for the horizontal.

EXAMPLE.

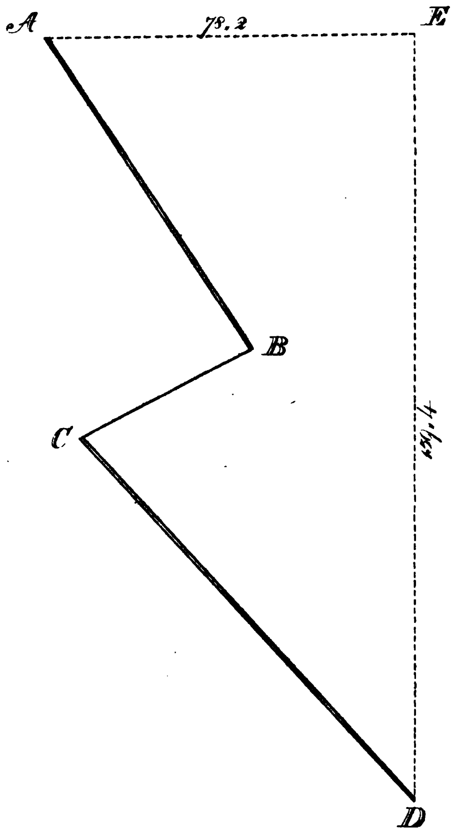
A shaft A B having been sunk 77 feet on a lode, which made an angle of 34° 45′, it was there found that a slide had severed or disjoined the lode and carried it downward from B to C 40 feet, on an angle of depression or declivity 59°. Here (at C) the lode was again discovered, and wrought 102 feet from C to D, on an angle of 42° 15′; required the depth of the vertical line D E, and length of the horizontal A E.

NOTE.

Should it be required to find the proper depth in the shaft D E from whence to drive a cross-cut to strike the end of the shaft A B, (where the slide first appeared)—the perpendicular of the first draft gives the depth, and the length of the cross-cut will be found by subtracting the base of the first draft from the horizontal line A E: and should it be necessary to make a drift from the shaft D E to the angle C, (where the lode was again discovered) the depth will be found by adding the perpendiculars of A and B together, and the bases of B and C will be the length of the drift.

Scale

40 FEET TO AN INCH.



XXII

THE FOREGOING EXAMPLE BY THE TABLES.

		BASE.			PERPENDICULAR.	
		ft.	in.		ft.	in.
∠ A 34° 45′	½	3 .	5,03977	½	4 .	11,15858
			12			12
		41 .	0,47724		59 .	1,90296
		1 .	8,51988		2 .	5,57929
	⅓	1 .	1,67992	⅓	1 .	7,71952
		43 .	10,67704		63 .	3,20177

		ft.	in.		ft.	in.
∠ B 59° 0′	½	5 :	1,71605	½	3 .	1,08274
			6			6
		30 .	10,29630		18 .	6,49644
	⅓	2 .	6,85802	⅓	1 .	6,54137
		0 .	10,28600		0 .	6,18045
		34 .	3,44032		20 .	7,21826

	ft,	in.	ft.	in.
∠ C 42° 15′	4 .	0,41041	4 .	5,2957
		4		4
	16 .	1,64164	17 .	9.1828
		4		4
	64 .	6,56656	71 .	0,7312
	4 .	0,41041	4 .	5,2957
	68 .	6,97697	75 .	6,0269

SUMMARY.

	BASES.			PERPENDICULARS.	
	ft.	in.		ft.	in.
∠ A	43 .	10,67704		63 .	3,20177
∠ C	68 .	6,97697		20 .	7,21826
	112 .	5,65401		75 .	6,0269
∠ B	34 .	3,44032			
Ans. A E =	78 .	2,21369	D E =	159 .	4,44693

HORIZONTAL DIALLING.

RULE—Observe which side of the triangle is given, and work by the specified case.

When there is more than one draft in the operation, add the sums of the respective sides together for the answer.

EXAMPLE 1.

Being required to put down a shaft 618 feet due east of an engine shaft at A, I am prevented from measuring in a direct line by intervening hills and wood: I therefore find it necessary, in order to avoid these obstructions, to go on an angle of 27° south of east from the shaft A. What distance must I proceed in this direction before I come at right angles with, or due south of, the eastern extremity of the given line, and how far must I then measure in a northerly direction to come exactly on the required spot. Or the question may stand thus:—Given the perpendicular 618 feet, angle 27°; the hypothenuse and base are required.

OPERATION.

	BASE.		HYPOTHENUSE.	
	ft.	in.	ft.	in.
∠ 27° =	3.	0,6858	6 .	8,8075
		10		10
	30 .	6,8580	67 .	4,0750
		10		10
(Multiplier 103 fath.)	305 .	8,5800	673 .	4,7500
	9 .	2,0574	20 .	2,4225
	314 .	10,6374	693 .	7,1725

EXAMPLE 2.

It being required to find the distance between two shafts A and B, which are inaccessible to a direct measurement on account of a marsh or lake lying in the way: I consequently measure 352 feet on an angle of 63° south of west, from A to C; at this station (C) I can see the shaft B, which I find by observation bears 29° north of west, and the line from C to B measures 615 feet; how far are these shafts apart in a right line? Or the question may stand simply thus:—

{Given angle 63°, hypothenuse 352 feet.}
{Given angle 29°, hypothenuse 615 feet.}

The sum of the perpendiculars † are required.

OPERATION.

		PERPENDICULAR.				PERPENDICULAR.		
		ft.	in.			ft.	in.	
∠ A 63°	½	2 .	8,68732	∠ C 29°	½	5 .	2,97262	
			11				10	
(Multiplier 58 fa. 4 ft.)		29 .	11,56052			52 ,	5,72620	(Multiplier 102 fa. 3 ft.)
			5				10	
		149 .	9,80260			524 .	9,26200	
		8 .	2,06196			10 .	5,94524	
		1 .	4,34366			2 .	7,48631	
	⅓	0 .	5,44788					
		159 .	9,65610			537 .	10,69355	

SUM.

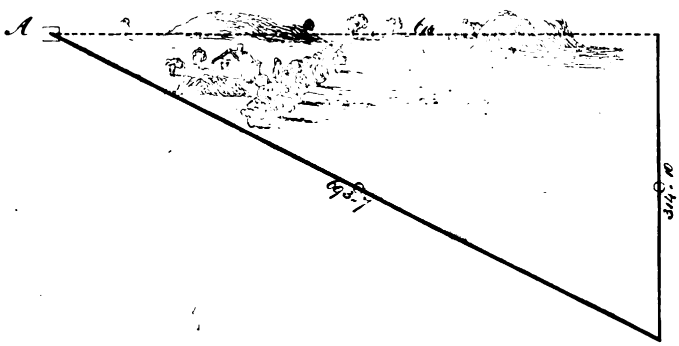
	ft.	in.
	159 .	9,65610
	537 .	10,69355
Ans. A. B.	697 .	8,34965

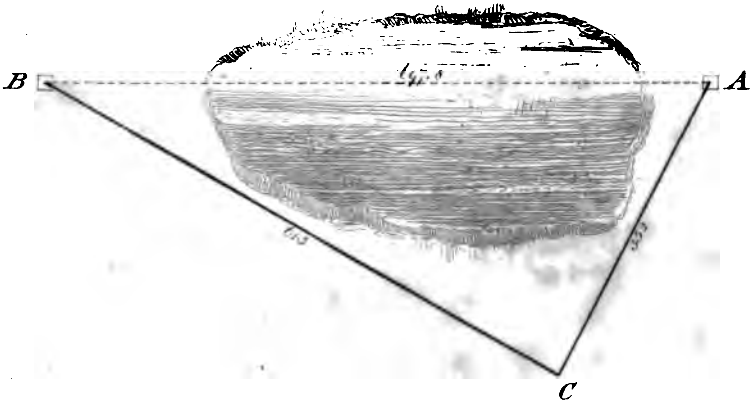
---

† As in this instance the perpendicular only is wanted, there is no necessity for taking out the other side.

Scale

200 FEET TO AN INCH





Budge, Del.

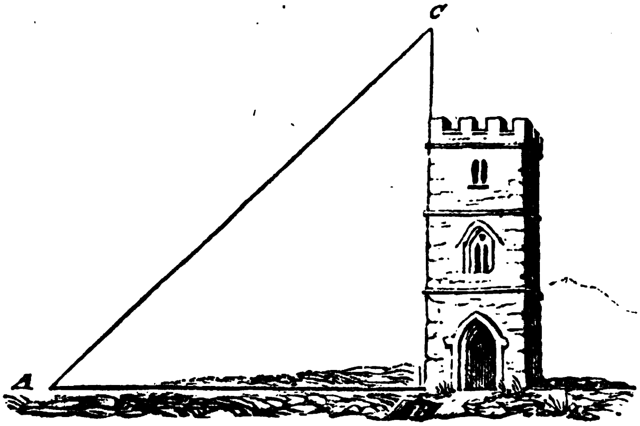
XXVI

VERTICAL DIALLING;

OR THE

MENSURATION OF HEIGHTS.

RULE—Observe the given side and angle, and work by the respective cases as heretofore.



EXAMPLE 1.

From the bottom of a tower at B, I measured 200 feet in a direct line B A on an horizontal plane, I then took the angle A 42° : required the height of the tower and staff B C.

OPERATION.

		PERPENDICULAR.	
		ft.	in.
Complement of ∠ A 42° is ∠ C 48°	$\frac{1}{3}$	5	4,82909
			11
		59	5,11999
			3
(Multiplier 53 fath. 2 ft.)		178	3,35997
		1	9,60969
Ans. B C		180	0,96966

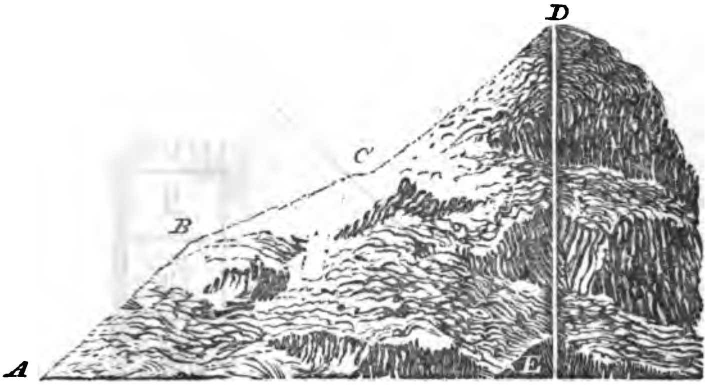
In operations of this nature the hypothenuse need not be regarded.

EXAMPLE 2.

Wanting to ascertain the height of an irregular hill, I proceed, from the several stations A, B, and C, to take the angles and measure the distances as follows, viz.:

From A to B ∠ 41° 0′ length 210 feet.
From B to C ∠ 22° 0′ length 216 feet.
From C to D ∠ 37° 30′ length 247 feet.

Required the altitude E D.



OPERATION.

		PERPENDICULAR.	
		ft	in.
∠ A 41° 0′ Comp. 49° 0′		3 .	11,23625
			7
6) 210 feet		27 .	6,65375
35 Multiplier			5
		137 .	9,26875
∠ B 22° 0′ Comp. 68° 0′		2 .	2,97167
			6
6) 216		13 .	5,83002
36 Multiplier			6
		80 .	10,98012
∠ C 37° 30′ Comp. 52° 30′	$\frac{1}{6}$	3 .	7,83082
			10
6) 247		36 .	6,30820
41 . 1 Multiplier			4
ft. in.		146 .	1,23280
A 137 . 9,26875		3 .	7,83082
B 80 . 10,98012		0 .	7,30513
C 150 . 4,36875		150 .	4,36875
Ans. height E D 369 . 0,61762			

MISCELLANEOUS EXAMPLES

IN THE FOREGOING RULES.

Given the hypothenuse 14 feet, 5 inches, angle 88° : required the base and perpendicular.*

ft. in.
Answer { Base = 14 . 4,89
Perp. = 0 . 6,03

Given the perpendicular 100 feet, angle 60° : required the hypothenuse and base.

ft. in.
Answer { Hyp. = 1666 . 8
Base = 173 . 2,428

Given the base 118 feet, angle (Comp.) 23° : required the hypothenuse and perpendicular.

ft. in.
Answer { Hyp. = 301 . 11,97
Perp. = 278 . 0,02

Given the angle 53° : required the underlay in a fathom.†

fath. ft. in.
Answer 1 . 1 . 11,5472

Given the angle 36° 45′: required the underlay in a fathom.

ft. in.
Answer 4 . 5,5650

---

* In single drafts, one or two figures of the decimal will be sufficient, the others may be rejected.

† It has been before observed, that the underlay is given in the base of the second table.

Given the angle 4° 15′: required the underlay in a fathom.

in.
Answer 5,3496.

A diagonal shaft having been sunk 1° 30′ out of its true course; what will be the extent of departure, supposing the length of the shaft 76 feet.

ft. in.
Answer 11 . 4,9577

Suppose a diagonal shaft was sunk as follows, viz.:

ft. in.
∠ 87° 0′ = 14 . 5
∠ 47° 0′ = 11 . 2
∠ 87° 30′ = 36 . 3
∠ 69° 30′ = 26 . 2
∠ 77° 30′ = 23 . 2
∠ 65° 30′ = 9 . 2

Required the sum of the bases and perpendiculars.

Answer { Perp. 52 . 8,45944
Bases 169 . 6,90784

Wanting to know the distance between two shafts, inaccessible in a right line, I measured from the first shaft 126 feet, on an angle of 27° 15′ E. by N.; from this station to the second shaft the line measured 91 feet, on an angle of 42° 30′ N. by W.: how far are the shafts apart?

ft. in.
Answer 179 . 1,3

Wanting to know the altitude of a precipice, I measure off from its base 66 feet, and from thence I take the angle to the summit, which I find to be 42°, (and consequently the complement 48°): required the height.

ft. in.
Answer 59 : 5,91999

At the foot of a hill the angle to the summit was 36°, from this place an adit had been driven in a direct line 218 feet; how far must I measure up the hill to put down a perpendicular shaft on the end of the adit, and what will be the depth of the shaft?

Answer {Hyp. or slope 281 . 5,54804
Perp. or shaft 158 . 4,62816

At the foot of a diagonal shaft, 28 fathoms in length, sunk on a lode 27° 45′ underlaying north, another lode was cut making an angle 48° 45′ underlaying south: what is the distance from the brace of the shaft to the back of the north lode?

FIRST TABLE.

	BASE.		PERPENDICULAR.	
	ft.	in.	ft.	in.
∠ 27° 45′	2	9,5	5	3,7
		7		7
	19	6,5	37	1,9
		4		4
	78	2,0	148	7,6

Divide this by 6 for the multiplier of the 2nd angle,
fath. ft. in.
which will be 24 . 4 . 7,6

THEN—SECOND TABLE.

		BASE.	
		ft.	in.
∠ 48° 45′ Comp. 41° 15′	½	5	3,14
			6
		31	6,84
			4
		126	3,36
	⅓	2	7,57
	½	0	10,52
	⅛	0	5,26
		0	0,65
		130	3,36

ANSWER.

	ft.	in.
Base of north lode	78	2
Base of south lode	130	3
Required distance	208	5

A perpendicular shaft having been sunk 168 feet in the side of a mountain, the slope or declivity making an angle with the shaft of 54° 15′: required to know how far I must measure down the hill to get at the right spot for driving an adit to come in the exact depth of the shaft,—the length of the adit is also required.

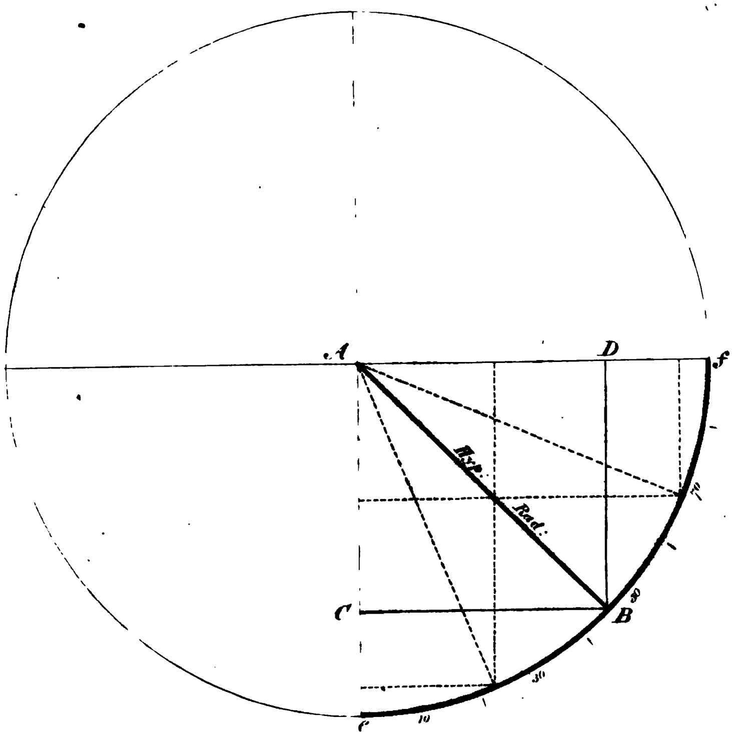
		ft.		in.
Answer	Slope	287	.	8,58
	Adit	233	.	4,40

A lode underlaying south was observed to make an angle of 17° 15′: required to know what distance from the back of the lode will be proper for sinking a perpendicular shaft that shall intersect the lode at the depth of 45 fathoms.

	ft.		in.
Answer	83	.	10,020

DIAGRAM

First Table



HYPOTHENUSE RADIUS,

ONE FATHOM.

ANGLE.		BASE.			PERPENDICULAR.				
Deg. °	Min. '	Feet.	Ins.	Decimals.	Feet.	Ins.	Decimals.		
1		0	1	,25057	5	11	,98903	89	
	15	0	1	,57067	5	11	,98286		45
	30	0	1	,88474	5	11	,97532		30
	45	0	2	,19877	5	11	,96642		15
2		0	2	,51276	5	11	,95614	88	
	15	0	2	,82771	5	11	,94449		45
	30	0	3	,14060	5	11	,93147		30
	45	0	3	,45442	5	11	,91708		15
3		0	3	,76819	5	11	,90132	87	
	15	0	4	,08188	5	11	,88420		45
	30	0	4	,39549	5	11	,86571		30
	45	0	4	,70902	5	11	,84584		15
4		0	5	,02246	5	11	,82461	86	
	15	0	5	,33581	5	11	,80201		45
	30	0	5	,64905	5	11	,77805		30
	45	0	5	,96219	5	11	,75272		15
5		0	6	,27521	5	11	,72602	85	
	15	0	6	,58811	5	11	,69793		45
	30	0	6	,90090	5	11	,66853		30
	45	0	7	,21354	5	11	,63773		15
6		0	7	,52605	5	11	,60558	84	
	15	0	7	,83842	5	11	,57205		45
	30	0	8	,15063	5	11	,53718		30
	45	0	8	,46269	5	11	,50093		15
7		0	8	,77459	5	11	,46333	83	
	15	0	9	,08633	5	11	,42435		45
	30	0	9	,39789	5	11	,38403		30
	45	0	9	,70926	5	11	,34234		15
8		0	10	,02046	5	11	.29930	82	
	15	0	10	,33147	5	11	.25490		45
	30	0	10	,64228	5	11	,20914		30
	45	0	10	,95288	5	11	,16203		15
9		0	11	.26328	5	11	,11356	81	
PERPENDICULAR.					BASE.			° ANGLE.	'

HYPOTHENUSE, ONE FATHOM.

ANGLE.		BASE.			PERPENDICULAR.				
°	′	Feet.	Ins.	Decimals.	Feet.	Ins.	Decimals.		
9	15	0	11	,57347	5	11	,06374		45
	30	0	11	,88343	5	11	,01256		30
	45	1	0	,19316	5	10	,96004		15
10		1	0	,50267	5	10	,90616	80	
	15	1	0	,80833	5	10	,85093		45
	30	1	1	,12096	5	10	,79435		30
	45	1	1	,42973	5	10	,73643		15
11		1	1	,73825	5	10	,67716	79	
	15	1	2	,04650	5	10	,61654		45
	30	1	2	,35449	5	10	,55458		30
	45	1	2	,66221	5	10	,46728		15
12		1	2	,96964	5	10	,42663	78	
	15	1	3	,27680	5	10	,36062		45
	30	1	3	,58365	5	10	,29331		30
	45	1	3	,89021	5	10	,22464		15
13		1	4	,19648	5	10	,15465	77	
	15	1	4	,50243	5	10	,08331		45
	30	1	4	,80807	5	10	,01062		30
	45	1	5	,11338	5	9	,93663		15
14		1	5	,41838	5	9	,86129	76	
	15	1	5	,72204	5	9	,78462		45
	30	1	6	,02736	5	9	,70663		30
	45	1	6	,33134	5	9	,62730		15
15		1	6	,63497	5	9	,54666	75	
	15	1	6	,93825	5	9	,46396		45
	30	1	7	,24116	5	9	,38139		30
	45	1	7	,54371	5	9	,29677		15
16		1	7	,84589	5	9	,21084	74	
	15	1	8	,14769	5	9	,12359		45
	30	1	8	,44910	5	9	,03502		30
	45	1	8	,75014	5	8	,94514		15
17		1	9	,05076	5	8	,85395	73	
	15	1	9	,35099	5	8	,76143		45
	30	1	9	,65082	5	8	,66762		30
	45	1	9	,95023	5	8	,57250		15
18		1	10	,24922	5	8	,47607	72	
								°	′
		PERPENDICULAR.			BASE.			ANGLE.	

HYPOTHENUSE, ONE FATHOM.

ANGLE.		BASE.			PERPENDICULAR.				
°	'	Feet.	Ins.	Decimals.	Feet.	Ins.	Decimals.		
18	15	1	10	,54779	5	8	,37833		45
	30	1	10	,84594	5	8	,27931		30
	45	1	11	,14364	5	8	,17897		15
19		1	11	,44091	5	8	,07734	71	
	15	1	11	,73772	5	7	,97441		45
	30	2	0	,03409	5	7	,87019		30
	45	2	0	,33000	5	7	,76467		15
20		2	0	,62545	5	7	,65787	70	
	15	2	0	,92043	5	7	,54977		45
	30	2	1	,21493	5	7	,44040		30
	45	2	1	,38655	5	7	,32973		15
21		2	1	,80249	5	7	,21779	69	
	15	2	2	,09554	5	7	,10457		45
	30	2	2	,38809	5	6	,99007		30
	45	2	2	,68013	5	6	,85270		15
22		2	2	,97167	5	6	,75724	68	
	15	2	3	,26270	5	6	,63892		45
	30	2	3	,55320	5	6	,51932		30
	45	2	3	,84320	5	6	,39847		15
23		2	4	,13264	5	6	,27635	67	
	15	2	4	,42156	5	6	,15297		45
	30	2	4	,70993	5	6	,02833		30
	45	2	4	,99776	5	5	,90243		15
24		2	5	,28508	5	5	,77528	66	
	15	2	5	,57176	5	5	,64686		45
	30	2	5	,85791	5	5	,51721		30
	45	2	6	,14350	5	5	,38631		15
25		2	6	,42852	5	5	,25416	65	
	15	2	6	,71295	5	5	,12077		45
	30	2	6	,99680	5	4	,98614		30
	45	2	7	,28006	5	4	,85027		15
26		2	7	,56272	5	4	,71317	64	
	15	2	7	,84479	5	4	,57483		45
	30	2	8	,12622	5	4	,43528		30
	45	2	8	,40708	5	4	,29448		15
27		2	8	,68732	5	4	,15247	63	
								°	'
		PERPENDICULAR.			BASE.			ANGLE.	

HYPOTHENUSE, ONE FATHOM.

ANGLE.		BASE.			PERPENDICULAR.				
°	'	Feet.	Ins.	Decimals.	Feet.	Ins.	Decimals.		
27	15	2	8	,96692	5	4	,00923		45
	30	2	9	,24590	5	3	,86478		30
	45	2	9	,52424	5	3	,71911		15
28		2	9	,80195	5	3	,57223	62	
	15	2	10	,07902	5	3	,42413		45
	30	2	10	,34823	5	3	,27483		30
	45	2	10	,63120	5	3	,12433		15
29		2	10	,90630	5	2	,97262	61	
	15	2	11	,18073	5	2	,81972		45
	30	2	11	,45450	5	2	,66561		30
	45	2	11	,72759	5	2	,51031		15
30		3	0	,00000	5	2	,35383	60	
	15	3	0	,27173	5	2	,19616		45
	30	3	0	,54276	5	2	,03730		30
	45	3	0	,81310	5	1	,87726		15
31		3	1	,08274	5	1	,71605	59	
	15	3	1	,35168	5	1	,55366		45
	30	3	1	,61990	5	1	,39009		30
	45	3	1	,88740	5	1	,22536		15
32		3	2	,15419	5	1	,05946	58	
	15	3	2	,42024	5	0	,89240		45
	30	3	2	,68557	5	0	,72418		30
	45	3	2	,95016	5	0	,55481		15
33		3	3	,21401	5	0	,38428	57	
	15	3	3	,47711	5	0	,21261		45
	30	3	3	,73946	5	0	,03978		30
	45	3	4	,00105	4	11	,86581		15
34		3	4	,26189	4	11	,69071	56	
	15	3	4	,52195	4	11	,51446		45
	30	3	4	,78125	4	11	,33709		30
	45	3	5	,03977	4	11	,15858		15
35		3	5	,29750	4	10	,97894	55	
	15	3	5	,55445	4	10	,79819		45
	30	3	5	,81062	4	10	,61632		30
	45	3	6	,06598	4	10	,43333		15
36		3	6	,32054	4	10	,24922	54	
								°	'
PERPENDICULAR.					BASE.			ANGLE.	

HYPOTHENUSE, ONE FATHOM.

ANGLE.		BASE.			PERPENDICULAR.				
°	'	Feet.	Ins.	Decimals.	Feet.	Ins.	Decimals.		
36	15	3	6	,57429	4	10	,06401		45
	30	3	6	,82724	4	9	,87770		30
	45	3	7	,07937	4	9	,69027		15
37		3	7	,33068	4	9	,50176	53	
	15	3	7	,58117	4	9	,31214		45
	30	3	7	,83082	4	9	,12144		30
	45	3	8	,07965	4	8	,92965		15
38		3	8	,32763	4	8	,73678	52	
	15	3	8	,57476	4	8	,54282		45
	30	3	8	,82105	4	8	,34779		30
	45	3	9	,06649	4	8	,25168		15
39		3	9	,31107	4	7	,95451	51	
	15	3	9	,55478	4	7	,75627		45
	30	3	9	,79763	4	7	,55697		30
	45	3	10	,03961	4	7	,35661		15
40		3	10	,28071	4	7	,15520	50	
	15	3	10	,52093	4	6	,95274		45
	30	3	10	,76026	4	6	,74923		30
	45	3	10	,99871	4	6	,54468		15
41		3	11	,23625	4	6	,33909	49	
	15	3	11	,47290	4	6	,13246		45
	30	3	11	,70864	4	5	,92481		30
	45	3	11	,94348	4	5	,71613		15
42		4	0	,17740	4	5	,50643	48	
	15	4	0	,41041	4	5	,29570		45
	30	4	0	,64250	4	5	,08396		30
	45	4	0	,87365	4	4	,87122		15
43		4	1	,10388	4	4	,65747	47	
	15	4	1	,33318	4	4	,44271		45
	30	4	1	,56153	4	4	,22696		30
	45	4	1	,78894	4	4	,01021		15
44		4	2	,01540	4	3	,79247	46	
	15	4	2	,24092	4	3	,57374		45
	30	4	2	,46547	4	3	,35403		30
	45	4	2	,68906	4	3	,13335		15
45		4	2	,91169	4	2	,91169	45	
								°	'
PERPENDICULAR.					BASE.			ANGLE.	

XXXIX

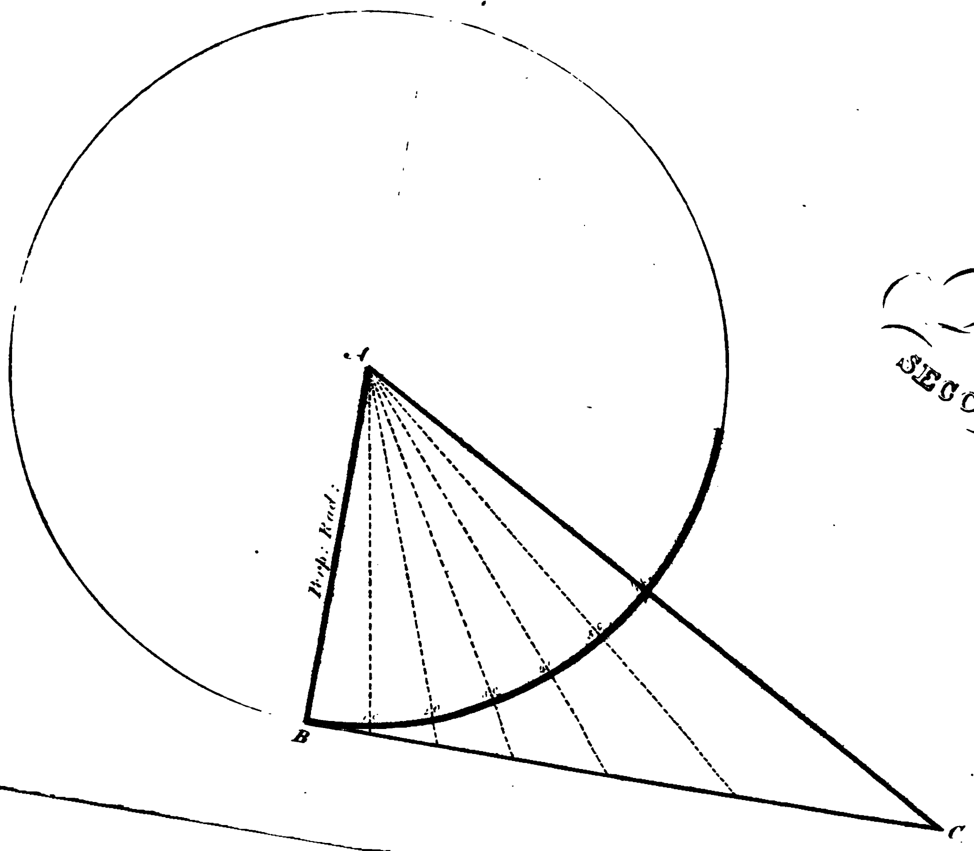


Diagram
SECOND TABLE

PERPENDICULAR RADIUS,

ONE FATHOM.

ANGLE.		BASE.				HYPOTHENUSE.			
Deg. °	Min. ′	Fath·	Feet.	Ins.	Decimals.	Fath·	Feet.	Ins.	Decimals.
1		0	0	1	,2568	1	0	0	,0108
	15	0	0	1	,5710	1	0	0	,0171
	30	0	0	1	,8854	1	0	0	,0247
	45	0	0	2	,1998	1	0	0	,0335
2		0	0	2	,5143	1	0	0	,0432
	15	0	0	2	,8289	1	0	0	,0554
	30	0	0	3	,1435	1	0	0	,0684
	45	0	0	3	,4582	1	0	0	,0828
3		0	0	3	,7728	1	0	0	,0986
	15	0	0	4	,0882	1	0	0	,1159
	30	0	0	4	,4035	1	0	0	,1346
	45	0	0	4	,7189	1	0	0	,1544
4		0	0	5	,0328	1	0	0	,1757
	15	0	0	5	,3496	1	0	0	,1980
	30	0	0	5	,6664	1	0	0	,2171
	45	0	0	5	,9825	1	0	0	,2484
5		0	0	6	,2993	1	0	0	,2736
	15	0	0	6	,6168	1	0	0	,3024
	30	0	0	6	,9336	1	0	0	,3312
	45	0	0	7	,2497	1	0	0	,3636
6		0	0	7	,5672	1	0	0	,3960
	15	0	0	7	,8841	1	0	0	,4298
	30	0	0	8	,2008	1	0	0	,4658
	45	0	0	8	,5212	1	0	0	,5026
7		0	0	8	,8402	1	0	0	,5400
	15	0	0	9	,1584	1	0	0	,5803
	30	0	0	9	,4788	1	0	0	,6192
	45	0	0	9	,7992	1	0	0	,6624
8		0	0	10	,1189	1	0	0	,7056
	15	0	0	10	,4393	1	0	0	,7531
	30	0	0	10	,7604	1	0	0	,7992
	45	0	0	11	,0808	1	0	0	,8474

PERPENDICULAR, ONE FATHOM.

ANGLE.		BASE.				HYPOTHENUSE.			
°	'	Fath	Feet	Ins.	Decimals.	Fath	Feet	Ins.	Decimals.
9		0	0	11	,4034	1	0	0	,8971
	15	0	0	11	,7259	1	0	0	,9482
	30	0	1	0	,0485	1	0	1	,0008
	45	0	1	0	,3696	1	0	1	,0548
10		0	1	0	,6936	1	0	1	,1088
	15	0	1	1	,0176	1	0	1	,1664
	30	0	1	1	,3416	1	0	1	,2262
	45	0	1	1	,6692	1	0	1	,2859
11		0	1	1	,9954	1	0	1	,3476
	15	0	1	2	,3215	1	0	1	,4106
	30	0	1	2	,6484	1	0	1	,4750
	45	0	1	2	,9760	1	0	1	,5410
12		0	1	3	,3036	1	0	1	,6085
	15	0	1	3	,6326	1	0	1	,6775
	30	0	1	3	,9617	1	0	1	,7481
	45	0	1	4	,2914	1	0	1	,8202
13		0	1	4	,6219	1	0	1	,8939
	15	0	1	4	,9538	1	0	1	,9691
	30	0	1	5	,2857	1	0	2	,0459
	45	0	1	5	,6178	1	0	2	,1242
14		0	1	5	,9496	1	0	2	,2042
	15	0	1	6	,2858	1	0	2	,2857
	30	0	1	6	,6192	1	0	2	,3688
	45	0	1	6	,9576	1	0	2	,4535
15		0	1	7	,2888	1	0	2	,5399
	15	0	1	7	,6294	1	0	2	,6338
	30	0	1	7	,9670	1	0	2	,7174
	45	0	1	8	,3062	1	0	2	,8087
16		0	1	8	,6456	1	0	2	,9015
	15	0	1	8	,9858	1	0	2	,9961
	30	0	1	9	,3271	1	0	3	,0443
	45	0	1	9	,6695	1	0	3	,1902
17		0	1	10	,0126	1	0	3	,2898
	15	0	1	10	,3560	1	0	3	,3911
	30	0	1	10	,7003	1	0	3	,4941
	45	0	1	11	,0472	1	0	3	,5988

PERPENDICULAR, ONE FATHOM.

ANGLE.		BASE.				HYPOTHENUSE.			
°	'	Fath.	Feet.	Ins.	Decimals.	Fath.	Feet.	Ins.	Decimals.
18		0	1	11	,3942	1	0	3	,7053
	15	0	1	11	,6220	1	0	3	,8135
	30	0	2	0	,0905	1	0	3	,9234
	45	0	2	0	,4204	1	0	4	,0352
19		0	2	0	,7916	1	0	4	,1487
	15	0	2	1	,1435	1	0	4	,2640
	30	0	2	1	,4965	1	0	4	,3811
	45	0	2	1	,8506	1	0	4	,5000
20		0	2	2	,2058	1	0	4	,6208
	15	0	2	2	,5622	1	0	4	,7434
	30	0	2	2	,9197	1	0	4	,8679
	45	0	2	3	,2783	1	0	4	,9942
21		0	2	3	,6262	1	0	5	,1224
	15	0	2	3	,9993	1	0	5	,2526
	30	0	2	4	,3615	1	0	5	,3846
	45	0	2	4	,7251	1	0	5	,5186
22		0	2	5	,0899	1	0	5	,6545
	15	0	2	5	,4560	1	0	5	,7924
	30	0	2	5	,8234	1	0	5	,9323
	45	0	2	6	,1921	1	0	6	,0741
23		0	2	6	,5622	1	0	6	,2179
	15	0	2	6	,9336	1	0	6	,3638
	30	0	2	7	,3065	1	0	6	,5117
	45	0	2	7	,6807	1	0	6	,6617
24		0	2	8	,0565	1	0	6	,8138
	15	0	2	8	,4336	1	0	6	,9679
	30	0	2	8	,8123	1	0	7	,1242
	45	0	2	9	,1924	1	0	7	,2826
25		0	2	9	,5741	1	0	7	,4432
	15	0	2	9	,9574	1	0	7	,6059
	30	0	2	10	,3422	1	0	7	,7708
	45	0	2	10	,7287	1	0	7	,9380
26		0	2	11	,1167	1	0	8	,1073
	15	0	2	11	,5065	1	0	8	,2789
	30	0	2	11	,8979	1	0	8	,4528
	45	0	3	0	,2910	1	0	8	,6290

PERPENDICULAR, ONE FATHOM.

ANGLE.		BASE.				HYPOTHENUSE.			
°	′	Fath.	Feet.	Ins.	Decimals.	Fath.	Feet.	Ins.	Decimals.
27		0	3	0	,6858	1	0	8	.8075
	15	0	3	1	,0824	1	0	8	,9883
	30	0	3	1	,4808	1	0	9	,1714
	45	0	3	1	,8810	1	0	9	,3571
28		0	3	2	,2831	1	0	9	,5450
	15	0	3	2	,6870	1	0	9	,7354
	30	0	3	3	,0928	1	0	9	,9283
	45	0	3	3	,5005	1	0	10	,1232
29		0	3	3	,9102	1	0	10	,3212
	15	0	3	4	,3219	1	0	10	,5220
	30	0	3	4	,7356	1	0	10	,7251
	45	0	3	5	,1514	1	0	10	,9303
30		0	3	5	,5692	1	0	11	,1384
	15	0	3	5	,9892	1	0	11	,3494
	30	0	3	6	,4112	1	0	11	,5625
	45	0	3	6	,8355	1	0	11	,7788
31		0	3	7	,2620	1	0	11	,9976
	15	0	3	7	,6907	1	1	0	,2192
	30	0	3	8	,1216	1	1	0	,4436
	45	0	3	8	,5550	1	1	0	,7008
32		0	3	8	,9906	1	1	0	,9008
	15	0	3	9	,4286	1	1	1	,1338
	30	0	3	9	,8691	1	1	1	,3696
	45	0	3	10	,3119	1	1	1	,6084
33		0	3	10	,7573	1	1	1	,8501
	15	0	3	11	,2053	1	1	2	,0949
	30	0	3	11	,6558	1	1	2	,3427
	45	0	4	0	,1088	1	1	2	,5937
34		0	4	0	,5646	1	1	2	,8477
	15	0	4	0	,9931	1	1	3	,1049
	30	0	4	1	,4842	1	1	3	,3653
	45	0	4	1	,9482	1	1	3	,6289
35		0	4	2	,4149	1	1	3	,8958
	15	0	4	2	,8846	1	1	4	,1660
	30	0	4	3	,3571	1	1	4	,4395
	45	0	4	3	,8326	1	1	4	,7165

PERPENDICULAR, ONE FATHOM.

ANGLE.		BASE.				HYPOTHENUSE.			
°	′	Fath.	Feet.	Ins.	Decimals.	Fath.	Feet	Ins.	Decimals.
36		0	4	4	,3111	1	1	4	,9969
	15	0	4	4	,7914	1	1	5	,2808
	30	0	4	5	,2772	1	1	5	,6819
	45	0	4	5	,5650	1	1	5	,8591
37		0	4	6	,2559	1	1	6	,1538
	15	0	4	6	,7501	1	1	6	,4520
	30	0	4	7	,2475	1	1	6	,7540
	45	0	4	7	,7483	1	1	7	,0597
38		0	4	8	,2526	1	1	7	,3693
	15	0	4	8	,7602	1	1	7	,6831
	30	0	4	9	,2834	1	1	8	,0000
	45	0	4	9	,7861	1	1	8	,3214
39		0	4	10	,3044	1	1	8	,6467
	15	0	4	10	,8265	1	1	8	,9761
	30	0	4	11	,3522	1	1	9	,3096
	45	0	4	11	,8818	1	1	9	,6473
40		0	5	0	,4152	1	1	9	,9893
	15	0	5	0	,9525	1	1	10	,0956
	30	0	5	1	,4938	1	1	10	,6863
	45	0	5	2	,0392	1	1	11	,0413
41		0	5	2	,5886	1	1	11	,4009
	15	0	5	3	,1420	1	1	11	,7651
	30	0	5	3	,7002	1	2	0	,1338
	45	0	5	4	,2624	1	2	0	,5049
42		0	5	4	,8291	1	2	0	,8855
	15	0	5	5	,4002	1	2	1	,2686
	30	0	5	5	,9758	1	2	1	,6566
	45	0	5	6	,5705	1	2	2	,0496
43		0	5	7	,1411	1	2	2	,4476
	15	0	5	7	,7308	1	2	2	,8507
	30	0	5	8	,3254	1	2	3	,2591
	45	0	5	8	,9250	1	2	3	,6727
44		0	5	9	,5296	1	2	4	,0918
	15	0	5	10	,1393	1	2	4	,5163
	30	0	5	10	,7542	1	2	4	,9463
	45	0	5	11	,3744	1	2	5	,3820

PERPENDICULAR, ONE FATHOM.

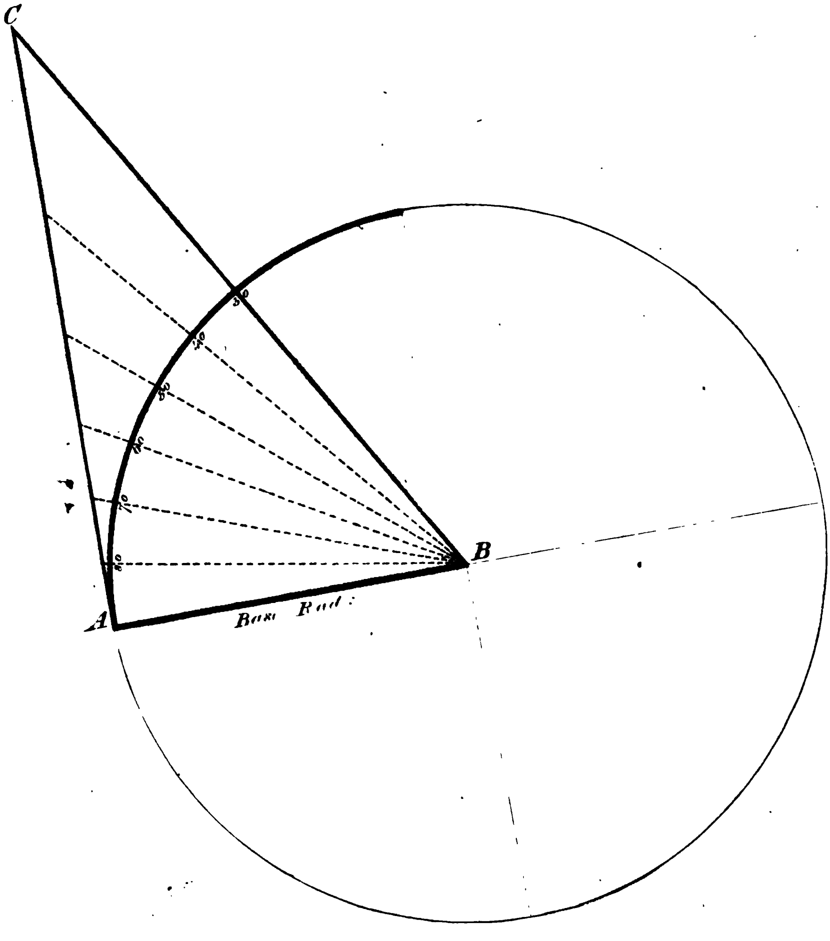
ANGLE.		BASE.				HYPOTHENUSE.			
°	′	Fath.	Feet.	Ins.	Decimals.	Fath.	Feet.	Ins.	Decimals.
45		1	0	0	,0000	1	2	5	,8234
	15	1	0	0	,6311	1	2	6	,2706
	30	1	0	1	,2677	1	2	6	,7237
	45	1	0	1	,9101	1	2	7	,1828
46		1	0	2	,5852	1	2	7	,6481
	15	1	0	3	,2122	1	2	8	,1195
	30	1	0	3	,8722	1	2	8	,5973
	45	1	0	4	,5382	1	2	9	,0814
47		1	0	5	,2105	1	2	9	,5721
	15	1	0	5	,8892	1	2	10	,0694
	30	1	0	6	,5742	1	2	10	,5735
	45	1	0	7	,2658	1	2	11	,0844
48		1	0	7	,9641	1	2	11	,6023
	15	1	0	8	,6692	1	3	0	,1273
	30	1	0	9	,3812	1	3	0	,6596
	45	1	0	10	,1003	1	3	1	,1991
49		1	0	10	,8265	1	3	1	,7462
	15	1	0	11	,5601	1	3	2	,3009
	30	1	1	0	,3012	1	3	2	,8634
	45	1	1	1	,0498	1	3	3	,4337
50		1	1	1	,8062	1	3	4	,0122
	15	1	1	2	,5699	1	3	4	,5987
	30	1	1	3	,3430	1	3	5	,1936
	45	1	1	4	,1236	1	3	5	,7970
51		1	1	4	,9126	1	3	6	,4091
	15	1	1	5	,7101	1	3	7	,0300
	30	1	1	6	,5164	1	3	7	,6599
	45	1	1	7	,3316	1	3	8	,2990
52		1	1	8	,1560	1	3	8	,9474
	15	1	1	8	,9893	1	3	9	,6053
	30	1	1	9	,8322	1	3	10	,2729
	45	1	1	10	,6848	1	3	10	,9505
53		1	1	11	,5472	1	3	11	,6381
	15	1	2	0	,4197	1	4	0	,3360
	30	1	2	1	,3024	1	4	1	,0445
	45	1	2	2	,1956	1	4	1	,7636

PERPENDICULAR, ONE FATHOM.

ANGLE.		BASE.				HYPOTHENUSE.			
°	′	Fath.	Feet.	Ins.	Decimals.	Fath.	Feet.	Ins.	Decimals.
54		1	2	3	,0995	1	4	2	,4937
	15	1	2	4	,0143	1	4	3	,2350
	30	1	2	4	,9403	1	4	3	,9876
	45	1	2	5	,8776	1	4	4	,7520
55		1	2	6	,8267	1	4	5	,5282
	15	1	2	7	,7876	1	4	6	,3165
	30	1	2	8	,7606	1	4	7	,1172
	45	1	2	9	,7458	1	4	7	,9306
56		1	2	10	,7444	1	4	8	,7570
	15	1	2	11	,7556	1	4	9	,6966
	30	1	3	0	,7801	1	4	10	,4497
	45	1	3	1	,8182	1	4	11	,3165
57		1	3	2	,8703	1	5	0	,1976
	15	1	3	3	,9365	1	5	1	,0932
	30	1	3	5	,0174	1	5	2	,0034
	45	1	3	6	,1131	1	5	2	,9287
58		1	3	7	,2241	1	5	3	,8697
	15	1	3	8	,3507	1	5	4	,8265
	30	1	3	9	,4933	1	5	5	,7994
	45	1	3	10	,6523	1	5	6	,7890
59		1	3	11	,7281	1	5	7	,7955
	15	1	4	1	,0211	1	5	8	,8194
	30	1	4	2	,2317	1	5	9	,8612
	45	1	4	3	,4604	1	5	10	,9212
60		1	4	4	,7077	2	0	0	,0000

DIAGRAM

Third Table



BASE RADIUS,

ONE FATHOM.

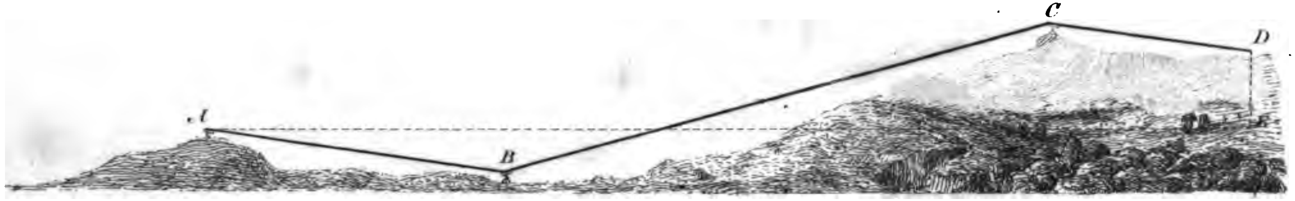
ANGLE.	HYPOTHENUSE.				PERPENDICULAR.			
Degrees.	Fath.	Feet.	Ins.	Decimals.	Fath.	Feet.	Ins.	Decimals.
1	57	1	9	,50554	57	1	8	,87726
2	28	3	11	,06698	28	3	9	,81022
3	19	0	7	,72726	19	0	5	,84186
4	14	2	0	,16226	14	1	9	,64795
5	11	2	10	,10734	11	2	6	,96374
6	9	3	4	,80760	9	3	1	,03424
7	8	1	2	,79665	8	0	10	,39294
8	7	1	1	,34135	7	0	8	,30662
9	6	2	4	,25663	6	1	10	,59011
10	5	4	6	,63148	5	4	0	,33229
11	5	1	5	,34070	5	0	10	,40789
12	4	4	10	’30087	4	4	2	’73337
13	4	2	8	’06963	4	1	11	’86626
14	4	0	9	’61672	4	0	0	’77622
15	3	5	2	’18664	3	4	4	’70766
16	3	3	9	’21278	3	2	11	’09384
17	3	2	6	’26186	3	1	7	’50139
18	3	1	4	’99690	3	0	5	’59321
19	3	0	5	’15185	2	5	5	’10318
20	2	5	6	’51392	2	4	5	’81837
21	2	4	8	’91082	2	3	7	’56641
22	2	4	0	’20164	2	2	10	’20626
23	2	3	4	’26994	2	2	1	’62137
24	2	2	9	’01872	2	1	5	’71465
25	2	2	2	’36651	2	0	10	’40450
26	2	1	8	’24438	2	0	3	’62187
27	2	1	2	’59363	1	5	9	’30796
28	2	0	9	’36392	1	5	3	’41231
29	2	0	4	’51190	1	4	9	’89144

BASE, ONE FATHOM.

ANGLE.	HYPOTHENUSE.				PERPENDICULAR.			
Degrees.	Fath.	Feet.	Ins.	Decimals.	Fath.	Feet.	Ins.	Decimals.
30	2	0	0	,00000	1	4	4	,70766
31	1	5	7	,79549	1	3	11	,82812
32	1	5	3	,86975	1	3	7	,22408
33	1	5	0	,19765	1	3	2	,87028
34	1	4	8	,75699	1	2	10	,74439
35	1	4	5	,52817	1	2	6	,82666
36	1	4	2	,49371	1	2	3	,09950
37	1	3	11	,63809	1	1	11	,54722
38	1	3	8	,94738	1	1	8	,15579
39	1	3	6	,40913	1	1	4	,91260
40	1	3	4	,01211	1	1	1	,80626
41	1	3	1	,74622	1	0	10	,82652
42	1	2	11	,60231	1	0	7	,96410
43	1	2	9	,57201	1	0	5	,21055
44	1	2	7	,64807	1	0	2	,55818
45	1	2	5	,82338	1	0	0	,00000
46	1	2	4	,09178	0	5	9	,52959
47	1	2	2	,44758	0	5	7	,14108
48	1	2	0	,88555	0	5	4	,82909
49	1	1	11	,40094	0	5	2	,58864
50	1	1	9	,98932	0	5	0	,41517
51	1	1	8	,64669	0	4	10	,30445
52	1	1	7	,36931	0	4	8	,25256
53	1	1	6	,15377	0	4	6	,25589
54	1	1	4	,99689	0	4	4	,31106
55	1	1	3	,89577	0	4	2	,41494
56	1	1	2	,84768	0	4	0	,56461
57	1	1	1	,85016	0	3	10	,75735
58	1	1	0	,90084	0	3	8	,99060
59	1	0	11	,99760	0	3	7	,26196
60	1	0	11	,13844	0	3	5	,56922

SCALE

40 YARDS TO AN INCH



XLIX

LEVELLING.

RULE—Add all the perpendiculars together for the base line or horizontal distance, and subtract the bases made by the angles of elevation and depression one from the other, for the perpendicular or difference of height. *

EXAMPLE.

Being required to level an irregular piece of ground, I measured in a S. W. direction 64 yards from A to B, on an angle of depression 9° 45′; from this station I measured 120 yards from B to C, in the same cardinal direction, on an angle of elevation 16° 30′; and from thence to the extent of the ground the line on the same course measured 44 yards from C to D, and the angle of depression 7° : required the base line or horizontal distance from the place where the levelling was begun, to the point where it was ended; also, how much higher or lower the ground is at the place where the operation terminated, than where it commenced.

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* The altitudes of irregular hills are generally ascertained by the assistance of a spirit level and perpendicular poles, and if the ground rise and descend alternately, the differences between the heights of the poles are added when ascending, and subtracted when descending, in order to determine the different elevations and depressions of the ground: the foregoing rule and method will be found far more correct and masterly, remembering always that the height of the instrument be accounted for, which may easily be done by taking the observation from a staff or target the same height as the instrument.

PERPENDICULARS.

	ft.	in.		fath.		ft.	in.
∠ 9° 45′ =	5 .	10,96004	×	32	=	189 .	2,72128
∠ 16° 30′ =	5 .	9,03502	×	60	=	345 .	2,10120
∠ 7° 0′ =	5 .	11,46333	×	22	=	131 .	0,19326
						3)665 .	5,01574
					A E	221 yds.	2 ft. 5 in.

BASES.

		ft.	in.		fath.		ft.	in.
Depression.	∠ 9° 45′ =	1 .	0,19316	×	32	=	32 .	6,18112
	∠ 7° 0′ =	0 .	8,77459	×	22	=	18 .	1,04098
							50 .	7,22210
Elevation.	∠ 16° 30′ =	1 .	8,44910	×	60	=	102 .	2,94600
							3) 51 .	7,72390
						E D	17 yds.	0 ft. 7½ in.

ANSWER.

	yds.	ft.	in.
Horizontal distance A E	221 .	2 .	5
Elevation E D ……………	17 .	0 .	7½

HORIZONTAL
OR
TRAVERSE DIALLING.

Plane sailing in navigation, and horizontal dialling in mining, are nothing more than the practice of right angled trigonometry, calling the hypothenuse the distance, the perpendicular the difference of latitude, the base the departure, and the angle opposite the base the course: consequently any range of dialling, however complicated and extensive, may be reduced into a single triangle, the perpendicular of which will either be the east and west, or north and south line, according to the main direction or bearing of the work; the hypothenuse will be the actual length of the dialling in a right line from the point of setting out to the termination; the base will be the distance the terminating point will fall right or left of the perpendicular; and the angle made by the hypothenuse with the perpendicular, will be the final course or direction of the work.

It therefore follows, that the general practice of repeating or retracing a course of underground dialling on the surface may be avoided, and thereby the difficulties and dangers arising from obstructions, irregular ground, and the attraction of the magnet by iron, which always abounds in the vicinity of a mine, be done away.

What is said of Mercator's sailing may, in the chief respect, be applied to horizontal dialling, viz.: "It is the art of finding on a plane surface the motion of a ship upon any assigned course by the compass, which shall be true in latitude, longitude, and distance sailed;" and certainly this includes the whole theory and practice of navigation; and if any method could be devised for measuring a ship's course and distance truly, nothing would be wanting:— also in dialling, it is only required to find a method for reducing the various windings and angles of a level or adit into a right line, and discovering the real extent and direction of that line, to complete the art.

But not to occupy the reader's time in telling him what he well knows already, we shall proceed to introduce the process for obtaining the length and bearing of a course of traverse dialling by the trigonometrical tables.

The first thing to be attended to is the statement of the work, or so placing the drafts that there may be no confusion in the operation, and that the perpendiculars and bases may fall on their proper sides.

In order to succeed in this essential matter, which may be considered the foundation of the work, note on which cardinal point the main direction of your dialling runs, whether east, west, north, or south, and reckon off your degrees right or left from that line: thus—if your dialling runs easterly or westerly, let the equator, or east and west line, be the point for numbering off your angles—if northerly or southerly, the meridian or north and south line; consequently this line will be the perpendicular of every triangle in the operation that comes within the sweep of half the circle, or 180 degrees; and should any of the drafts return beyond the north or south points, or exceed

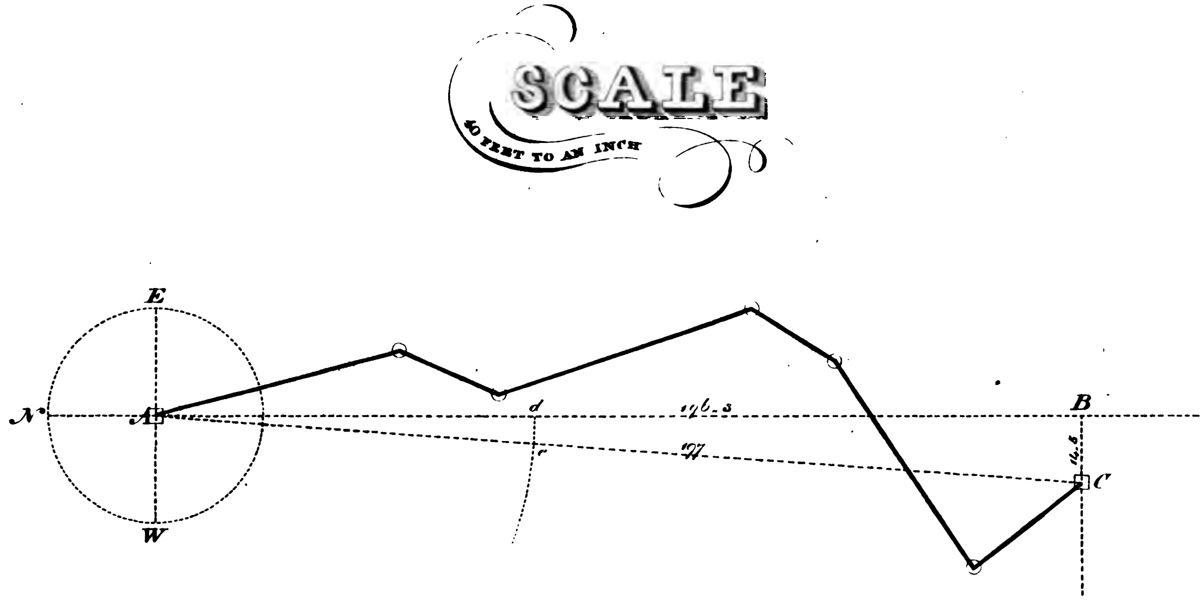
90 degrees right or left of the east point, then the angle must be counted from the west toward the north or south, as the draft may happen to incline.

This being done it is evident that on a course of east and west dialling, the bases north and bases south must be subtracted one from the other, and the remainder will be the departure or base line, north or south as the dialling may have prevailed on this or that side, and if any of the drafts have gone westerly, then the perpendiculars west must be subtracted from the perpendiculars east, for the real length of the perpendicular; but if the dialling has prevailed most in a westerly direction, the perpendicular will lie on that side: in short, as a matter of course, either for the difference of latitude, or rather difference of longitude in this case, (the perpendicular) or for the departure, (the base) the lesser number must be taken from the greater, and the differences will shew the sides on which the operation lies.

This process must all be performed by the first table, where the hypothenuse is given, because in every case the actual measured line will be the longest side of the triangle, and after stating the work, as before directed, take out the numbers standing against the given angles in the table and multiply them respectively by the length of the hypothenuse, reduced into fathoms and parts, (if any) and place them in their proper positions until the whole has been calculated; then take the sum of the bases north and south one from the other, and the sum of the perpendiculars east and west one from the other, the perpendicular remainders will shew the east and west line, and the bases the distance the dialling has extended north or south of that line.

The work is now brought to that case where the difference of latitude and departure are given to find the course and distance, and in order to avoid the necessity of introducing extensive and intricate tables, used by navigators for this purpose, we shall have recourse to one simple act of instrumental operation, and as two sides of the triangle are given, the thing may be quickly and safely performed; thus—draw the base the given length by a scale of equal parts, raise the perpendicular on one end of the base, (and of course at right angles therewith) and mark off the given length, draw the hypothenuse, and the triangle will be complete: then, by the same scale, measure the hypothenuse, and it will be the actual length of the dialling in a right line, from beginning to end; then, with a protractor or scale of chords, measure the angle opposite the departure or base, and it will be the true course, bearing, or direction of the extreme points.

The degrees on the miner's compass are generally graduated from 1 to 360, and are figured toward the left hand, consequently 90° stands at the west point, 180° at south, 270° at the east, and ends with 360° at the north; and when the same course is to be pursued, that is, when the angles are to be taken and the drafts measured again, there will be no necessity for finding the real direction of the line, for as the sights are always fixed, the dialler need only be careful to observe that the needle stands at the same degree as in the original course: but when the operation is to be plotted or trigonometrically proved, there will be a necessity for ascertaining the actual bearing of every draft in the work, and this may be done by the following rule.



LV

RULE.

(SIGHTS FIXED NORTH AND SOUTH.)

When the needle rests on any degree	From 1 to 90 N. to W.	The direction of the sights or course of the dialling will be	E. of N. Comp. N. of E.
	From 90 to 180 W. to S.		S. of E. Comp. E. of S.
	From 180 to 270 S. to E.		W. of S. Comp. S. of W.
	From 270 to 360 E. to N.		N. of W. Comp. W. of N.

EXAMPLE 1.

It is required to sink a perpendicular shaft on the end of a level whose angles and drafts measured as follows, viz.:

	ft.	in.		fath.	ft.	in.
∠ 16° 30′ E. of S.	53	6	or	8	5	6
∠ 26° 0′ W. of S.	22	11	or	3	4	11
∠ 19° 0′ E. of S.	58	0	or	9	4	0
∠ 34° 30′ W. of S.	21	6	or	3	3	6
∠ 57° 30′ W. of S.	53	8	or	8	5	8
∠ 39° 30′ E. of S.	29	10	or	4	5	10

What distance is the end C (in the annexed plate) where the dialling was finished, from the engine shaft A where the dialling was begun, and what is the bearing of the line A C, or how many degrees are contained in the angle B A C?

OPERATION.

BASES.

	ft.	in.		fath.	ft.	in.		ft.	in.
E. of S. 16°½ =	1	8,44910	×	8	5	6	=	15	2,33790
W. of S. 26° =	2	7,56272	×	3	4	11	=	10	0,53916
E. of S. 19° =	1	11,44091	×	9	4	0	=	18	10,58864
W. of S. 34°½ =	3	4,78125	×	3	3	6	=	12	2,13236
W. of S. 57°½ =	5	0,72418	×	8	5	8	=	45	8,18762
E. of S. 39°½ =	3	9,79763	×	4	5	10	=	18	11,55815

	ft.	in.
Sum of bases W. of S.	67	5,85913
Sum of bases E. of S.	53	0,48469
Base or departure Westerly B C =	14	5,37444

PERPENDICULARS.

		ft.	in.		fath.	ft.	in.		ft.	in.
∠ 16°½	=	5 .	9,03502	×	8 .	5 .	6	=	51 .	3,56228
∠ 26°	=	5 .	4,71317	×	3 .	4 .	11	=	20 .	7,16851
∠ 19°	=	5 .	8,07734	×	9 .	4 .	0	=	54 .	10,06606
∠ 34°½	=	4 .	11,33709	×	3 .	3 .	6	=	17 .	8,62417
∠ 57°½	=	3 .	2,68557	×	8 .	5 .	8	=	28 .	10,05018
∠ 39°½	=	4 .	7,55697	×	4 .	5 .	10	=	23 .	0,04485
Perpendicular or diff. of latitude, A B									196 .	3,51605

THEN—BY CONSTRUCTION.

Draw two lines at right angles, as A B and B C, and of an indefinite length, take 196 feet, 3½ inches, in your compasses from a scale of equal parts, and with one foot in the right angle B, point off the distance B A for the perpendicular. Again take 14 feet, 5¼ inches from the same scale and apply it to the other line B C for the base; draw the hypothenuse to join A C, which by the same scale will be found to measure 197 feet.

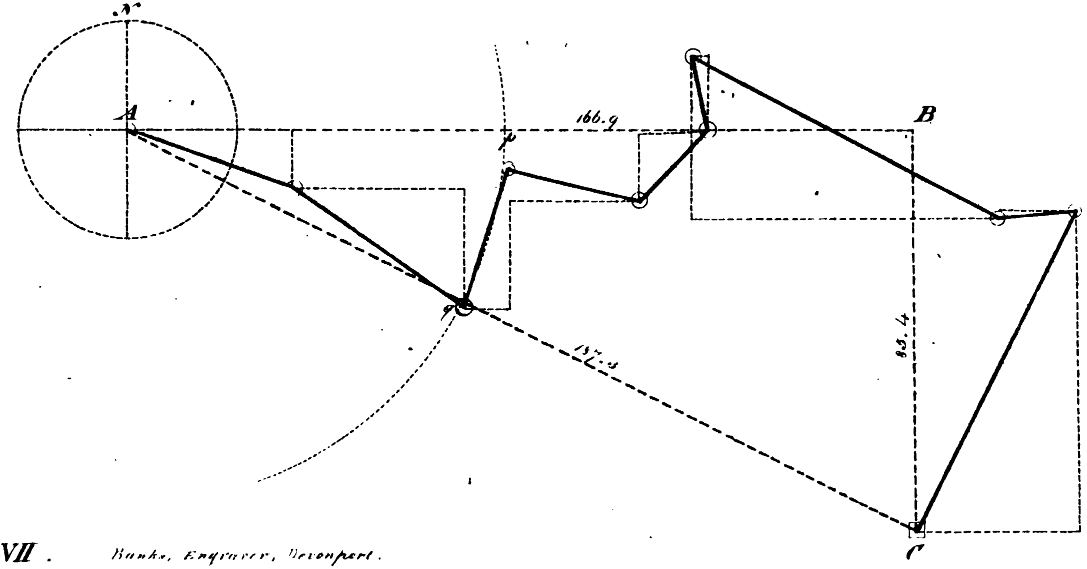
FOR THE ANGLE.

With the chord of 60° in your compasses and centre A, describe an arc *e d* cutting A B and A C in *d* and *e*; then take the distance *e d* in your compasses, and setting one foot on the brass pin at the beginning of the chords on your scale, observe how many degrees the other foot reaches to, which will be 4° 15′ for the arc *e d* or angle B A C.

ANSWER.

197 feet, on an angle of 4° 15′ west of south.

Scale
40 feet to an inch



LVII. Banks, Engraver, Devonport.

EXAMPLE 2.

Given the following course of traverse dialling, viz.:

Degrees at which the needle stood on the outer circle of the dial.				ft.	in.		fath.	ft.	in.
162°	= ∠ 18°	0′	S. of E.	36 .	0	or	6 .	0 .	0
143°¾	= ∠ 36°	15′	S. of E.	44 .	4	or	7 .	2 .	4
16°½	= ∠ 73°	30′	N. of E.	30 .	9	or	5 .	0 .	9
257°¼	= ∠ 12°	45′	S. of E.	28 .	6	or	4 .	4 .	6
45°	= ∠ 45°	0′	N. of E.	17 .	10	or	2 .	5 .	10
7°¾	= ∠ 82°	15′	N. of W.	15 .	3	or	2 .	3 .	3
152°½	= ∠ 27°	30′	S. of E.	72 .	0	or	12 .	0 .	0
87°½	= ∠ 2°	30′	N. of E.	16 .	0	or	2 .	4 .	0
204°½	= ∠ 65°	30′	S. of W.	73 .	0	or	12 .	1 .	0

Required the distance and bearing of the extreme points A C.

OPERATION.

BASES SOUTHERLY.

		ft.	in.		fath,	ft.	in.		ft.	in.
18°	0′	= 1 .	10,24922	×	6 .	0 .	0	=	11 .	1,49522
36°	15′	= 3 .	6,57429	×	7 .	2 .	4	=	26 .	2,57669
12°	45′	= 1 .	3,89021	×	4 .	4 .	6	=	6 .	3,44849
27°	30′	= 2 .	9,24590	×	12 .	0 .	0	=	33 .	29,5080
65°	30′	= 5 .	5,51721	×	12 .	1 .	0	=	66 .	5,12605
									143 .	3,59725

BASES NORTHERLY.

		ft.	in.		fath.	ft.	in.		ft.	in.
73°	30′	= 5 .	9,03502	×	5 .	0 ,	9	=	29 .	5,80448
45°	0′	= 4 .	2,91169	×	2 .	5 .	10	=	12 .	7,14507
82°	15′	= 5 .	11,34234	×	2 .	3 .	3	=	15 .	1,33685
2°	30′	= 0 .	3,14060	×	2 .	4 .	0	=	0 .	8,37150
									57 .	10,65790

		ft.	in.
From bases southerly	=	143 .	3,59725
Subtract bases northerly	=	57 .	10,65790
Departure B C		85 .	4,93935

PERPENDICULARS EASTERLY.

		ft.		in.		fath.	ft.	in.		ft.		in.
18° 0′	=	5	.	8,47607	×	6 .	0 .	0	=	34	.	2,85612
36° 15′	=	4	.	10,06401	×	7 .	2 .	4	=	35	.	9,02851
73° 30′	=	1	.	8,44910	×	5 .	0 .	9	=	8	.	10,80163
12° 45′	=	5	.	10,22464	×	4 .	4 .	6	=	27	.	9,56704
45° 0′	=	4	.	2,91169	×	2 .	5 .	10	=	12	.	7,14507
27° 30′	=	5	.	3,86478	×	12 .	0 .	0	=	63	.	10,37736
2° 30′	=	5	.	11,93147	×	2 .	4 .	0	=	15	.	11,81724
										199	.	1,59327

PERPENDICULARS WESTERLY.

		ft.		in.		fath.	ft.	in.		ft.		in.
82° 15′	=	0	.	9,70926	×	2 .	3 .	3	=	2	.	0,67815
65° 30′	=	2	.	5,85791	×	12 .	1 .	0	=	30	.	3,27124
										32	.	3,94939

	ft.	in.
From perpendiculars east =	199 .	1,59327
Subtract perpendiculars west =	32 .	3,94939
A B	166 .	9,64388

	ft.	in.
Perp. or east and west line, A B	166 .	9,64388
Base south of east C B....................	85 .	4,93935

Then by construction (as before) the hypothenuse A C will be found 187 feet, 3 inches, and the angle *p q* 27 degrees, south of east.

PART THE SECOND

OF THE

PRACTICAL MINER'S GUIDE.

INTRODUCTION.

THE qualifications necessary to constitute an accomplished miner are more numerous and difficult of attainment than is generally imagined, even by persons deeply interested in mining affairs; and although it may not be expected that every one who fills a mining situation should be an adept in all the various branches of the art, yet it is certainly highly desirable that agents, who have the management of large adventures, should possess a general knowledge of every thing connected with the profession of a miner.

The following miscellaneous subjects are essential to the practical miner, and require no comment to set forth their utility; they may also be found useful and interesting to persons not immediately engaged in mining pursuits.

The first article consists in a description of the art of assaying silver; and as this has hitherto been a secret in the possession of but few persons, it is expected that it will form an acceptable part of the work, especially as it will come abroad at a time, when foreign mining speculations (where the seat of action is principally among the precious metals) abound beyond all precedent.

The next part of the work contains a plain statement of the method of assaying copper, including the established process of one of the most experienced and respectable copper-assayers in the county of Cornwall.—Rules for assaying lead and tin follow in succession, and this part of the treatise concluded with a description of the manner of extracting silver from copper ore, or of discovering the quantity of silver it contains; and probably this article also may be productive of beneficial effects to the mining interest, as there is great reason to believe that a considerable proportion of silver is contained in the ores produced from many of our copper mines. The method is very simple, and the trial may be quickly and satisfactorily made.

The subsequent part of the work is described in the table of contents.

ASSAY OF SILVER ORE.

Sample,—1 ounce avoirdupois, pulverised and sifted through a fine hair sieve, then well mixed in the scoop with the following flux, viz.:

Red lead *	2 oz.
Red tartar	5 dwts.
Nitre	9 dwts.
Borax	4 dwts.
Lime	¼ oz.
Salt	2 oz.
Fluor spar (bruised)	¼ oz.

Smelt the ore in a wrought-iron crucible; if this cannot be conveniently procured, and a stone pot used, add 1 ounce of iron. The sample will melt in a good heat in about 12 minutes, if the ore is tolerably free from sulphur and iron, otherwise it will require more time.

When the sample has become quite fluid, take it out and pour it in a mould prepared to receive it, having

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* An ounce of red lead generally contains about 1-32nd part of a grain of silver, or nearly 3 ounces of silver in a ton. Derbyshire lead ore is preferred, by some assayers, to red lead.

The proportion of silver contained in the flux must first be known, and the regular deduction made from the produce, in order to obtain a true assay.

been anointed on the inside with grease or oil; the process of taking out and pouring the sample must be done quickly, otherwise a degree of chill will take place, so that the metal will not run freely out of the crucible, and the assay will in consequence be imperfect.

If the operation has been properly managed, the lump will separate clean from the slag or dross by a slight blow; but if the metal and dross stick together, the assay is impure:—it is probable a little more nitre would remedy this defect.

Should the lump when broken display the metal disseminated throughout and uncombined among the slag, it is a proof the sample was not sufficiently flowed, or not kept time enough in the furnace.

If the heat is too strong, or the sample left too long time in the fire, it will set, or become dry and callous, and this change will take place to all appearance quite suddenly. Either the former circumstance of too low a heat, or this of too high, renders the assay irremediable.

Should the sample appear stubborn and refuse to melt in a brisk heat, add more nitre.

TESTING OR REFINING PROCESS.

The test or cupel should be composed of four-fifths bone ashes to one-fifth fern ashes, damped and well beat into an iron ring 2½ inches deep, and 6 inches in circumference.

The test should be put in the fire an hour or more before the refining process is begun, otherwise the silver will be apt to be agitated by the unsettled test, spring over, and consequently the assay be destroyed.

Should the assay set in refining before it has become pure, throw in about half an ounce of potter's lead. *

If the fire is permitted to get low, or too much air admitted into the furnace, the assay will be apt to turn to litharge; whenever this happens, increase the fire by putting in a few pieces of sea-coal, instead of coke, at the same time sprinkle a little coal-dust on the test.

When the assay is thoroughly pure or fine it will assume a globular shape, set, or become fixed, and in a few moments will throw up sprouts or branches from the top. Take out the test, weigh the prillion, find in the table the produce or value per ton, and the work will be complete.

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* The fire should be gradually increased toward the close of the process. A muffle or arched cover to the test would prevent the air from taking an unfavourable effect on the assay, while the furnace is opened for the purpose of increasin g the fire, by adding coal, wood, or coke.

ASSAY OF COPPER ORE.

Sample,—400 grains pounded well in a mortar and sifted through a fine hair sieve, put in an earthen crucible, and frequently stirred while in the furnace with an iron rod or paddle. The sulphur will be seen to go off in white fumes; the process must be continued until this evaporation ceases, or nearly so, which will generally occupy from one to two hours. Great attention must be paid during this operation in order that a standard regal may be obtained, which being done, there will be no danger of producing a true assay. The ore, during the process, must be kept in a free, sandy state, which will be effected by stirring, and constant regulation of the degree of heat. If the ore becomes moist and begins to stick or adhere to the crucible, it must be immediately taken out of the fire and stirred a short time till this effect has ceased, and then returned. When it has become tolerably free of sulphur, it may be discovered by the evaporation having nearly ceased.* This being observed, take it out of the fire, and let it gradually cool in the crucible; and if, when cold, the upper part appears red or brown, and the under part black, it is a proof of its having been well calcined.

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* It is only some very stubborn ores, containing a mixture of metals, or semi-metals, which require to be so effectually roasted or calcined.

This being done, add standard flux, viz.:

Borax	5 dwts.
Lime	1½ ladle.[*]
Fluor spar (pulverized)	1 ladle.

Mix these together with the calcined ore in the crucible, and cover the whole with salt, let it melt well, and a regal will be produced.

MARKS AND REMARKS.

A good or standard regal is brown, and full of cracks or fissures, and of a spherical shape. Should it come out flat, it is a mark of its not having been well calcined, and may be thrown back again with a small quantity of nitre.

Should a regal come out too low or coarse, (having, when broken, a cinder-like, or cellular appearance) throw it back with additional nitre: if too high or fine, (having, when broken, a metallic appearance) return it to the crucible with a ladle of sulphur; in either case let it work well together a short time, and in all probability a standard regal will be produced.

A regal may be considered good, which will produce from 8 to 12 in 20, and this quality is easily known by inspection; but if less than 8, or above 12, it would be better to reject it, and begin the process again with a new sample.

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[*] Common assaying ladle—diameter ¾ inch, depth ½ inch.

Grey, black, and green ores, require a proportion of sulphur, in order to throw them back, as they contain too little of this mineral in their composition to produce a good assay.

Should a regal be too fine, put less nitre with it in refining; and therefore the coarser it is, the more nitre will be required.

FINING PROCESS.

Pound or pulverize the regal, put it in an earthen fining pot, and re-calcine it until perfectly sweet, (*i. e.* free from sulphur) which may be discovered both by the appearance and fumigation. Then add

Nitre	3 dwts.	Covered or sprinkled over with salt.
Red tartar	10 ditto.	
Borax	5 ditto.	
Salt	2 ladles.	

This brings down the assay into coarse copper. Should it come out having a transparent or horn-like appearance, add 4 dwts. of nitre and a ladle of salt, letting it work well in the fire. Should the assay come out black, plate it, and if the black flies off in flakes or scales, it is a proof of its not having been sufficiently calcined; if not, its colour may be attributed to lead, or a mixture of metals; the former defect renders the assay hopeless.

Should it come out clean, put the assay in the pot without flux, and when fluid, take out the pot and shake it gently until the surface assumes an azure or blue appearance; then put

Refining flux * .... 5 dwts.
(viz.: 2 parts nitre, to 1 part white tartar)
Salt .... 1 ladle.

Preparatory to pouring into the crucible, place the refining flux in the mouth or fore part of the scoop, and the salt behind; throw it in with the assay and let it melt until the flux settles well down, then pour the copper into one mould, and the slag or scoria into another: return the slag into the same pot with 2 ladles of red tartar, and let it melt well down; take out the prillion and weigh it with the lump for the produce, and the work will be completed.

---

* The refining flux should go through a calcining process before it is used; it may be done by putting two parts nitre to one part white tartar in an iron mortar, to which apply a red-hot iron and stir it therewith until the deflagration has ceased, when cold, powder and sift it.

This operation will prevent any commotion during the refining, which otherwise may be so violent as to cause some of the metal to spring out of the crucible, and thereby the assay be spoiled.

ASSAY OF LEAD ORE.

Sample—1 oz. avoirdupois.

FLUX.

1	common ladle	red tartar.
1	ditto	spar.
2	ditto	salt.
½	ditto	borax.
¾	ditto	nitre.
½	ditto	lime.

Mix the flux with the sample and put it in an iron crucible, stir it with an iron rod during the latter part of the process; in about five minutes, in a brisk heat, the sample will be down, provided the crucible was red-hot when the assay was thrown in, which should always be the case.

If the sample, to be tried, weighs four ounces, the proportionate quantity of flux must be added agreeably with the above statement.

It may be discovered when the sample is ready, by the grating of the rod against the bottom of the crucible in stirring—it should then be immediately taken out and poured. The metal will separate clean from the slag in a good assay.

To assay lead ore for discovering the quantity or proportion of silver it contains, the foregoing method must first be used, and the assay then tested precisely the same way as described for refining a silver sample, page 64. The lead will go off in vapour, and the silver remain in the test.

ANOTHER METHOD OF ASSAYING LEAD ORE.

Take of clean, pulverized slag 1½ ounce, iron 1 ounce, lead ore 1 ounce, mix the ore and slag together, and in about six minutes the assay will be in a fluid state, and with proper care, the produce will be found equally correct, by this simple method, as by the foregoing general and expensive process.

ASSAY OF TIN ORE.

Sample—Two ounces black tin.

FLUX.

Culm	⅓ weight of sample.
Borax	4 dwts.

PROCESS.

If the ore contains a large proportion of iron, add more culm; * when the sample is properly down, or flowed, the surface of the assay in the crucible will be perfectly smooth and motionless; in a strong heat this will occur in about twelve minutes.

When taken out of the fire, stir it well with an iron rod before you pour it; afterwards scrape the crucible, pulverize the scrapings in a mortar, and then van or wash them on a shovel. The prillion of a standard sample will not exceed 2 in 20.

The criterion for the lump is its possessing a malleable quality, or bending to the hammer without breaking.

Grain tin may be treated in every respect as the above, except in the subsequent addition of culm, which will not be required.

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* If the sample is very stubborn, add a small quantity of pulverized fluor, with the culm.

METHOD OF DISCOVERING THE PROPORTION OF SILVER CONTAINED IN COPPER ORE.

Sample—One ounce.

FLUX.

1	ladle	red tartar.
1	ditto	nitre.
½	ditto	lime.
½	ditto	borax
1	ditto	fluor
1	ditto	red lead.

Well mixed with the ore and melted in a wrought iron crucible,* about eight minutes, in a brisk heat, will be sufficient; the last five minutes the assay should be incessantly stirred with an iron rod: pour the sample and cool it, then break out the lump, and test it in the usual way.

REMARKS.

Soon as the assay begins to flow, the lead, by the power of affinity, will presently attract the silver, or the silver, by the same law, will attach itself to the lead, and this being effected, it only requires the process of refining, or burning off the inferior metals, to find the produce.

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* If a stone crucible be used, one ounce of iron must be added to the flux.

SMELTING SILVER ORE.

Calcine the ore in a paddle furnace, with a proportion of lime; about sixteen hours will compleat the work; during the whole process the ore must be stirred continually.

Then for refining, take a black-lead pot, large enough to contain two gallons wine measure, let it be nearly filled with the calcined ore, ½ lb. of nitre, and 2 lbs. of pulverized fluor.

Let it remain in the pot furnace one hour, in a white heat, and then pour it in a mould; the silver will sink to the bottom, and the slag remain on the top, which, when cold, will separate of itself.

SMELTING LEAD AND SILVER ORE.

CALCINING PROCESS.

Take such quantity of silver ore as your calcining furnace will contain, cover it over with lime, force the fire and make it red hot, then let it be well stirred or paddled; if it begins to flow, add more lime: this process will occupy nearly 18 hours, and the ore must be kept in action the whole time.

THEN FOR THE SMELTING PROCESS.

Take a quantity of slag, put it in the flowing furnace and let it melt, then diminish the heat, that it may cool and form a crust or artificial lining to the furnace, which will prevent the metal from penetrating and escaping.

Put in the calcined ore, and stop the furnace doors close with mortar, increase the fire until the charge flows, which will require about 5 hours fervent heat; this done, open all the doors, reduce the fire, and throw in the furnace about 2 bushels* of sea-coal, sifted through a half-inch guage sieve: the charge will dry up in about half an hour, then stop the doors again and increase the fire; in about 6 hours the charge will be fit to be tapped and drawn off.

The silver and lead will flow and combine together; the separation may afterwards be made by means of a blast-furnace, whereby the lead will be converted into litharge, and consequently entirely detached from the silver.

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* This will be sufficient for 8 cwt. of calcined ore.

A TABLE

SHEWING THE NUMBER OF OUNCES AND PARTS OF AN OUNCE OF SILVER CONTAINED IN A TON OF ORE, BY ASSAY PRODUCED FROM ONE OUNCE AVOIRDUPOIS.

ASSAY.	PER TON.			ASSAY.	PER TON.			ASSAY	PER TON.		
grs pts	oz.	dwts.	grs.	grs.	oz.	dwts.	grs.	grs.	oz.	dwts.	grs
1/32	2	6	16	3 3/8	252	0	0	6 7/8	513	6	16
1/16	4	13	8	1/2	261	6	16	7	522	13	8
1/8	9	6	16	5/8	270	13	8	1/8	532	0	0
1/4	18	13	8	3/4	280	0	0	1/4	541	6	16
3/8	28	0	0	7/8	289	6	16	3/8	550	13	8
1/2	37	6	16	4	298	13	8	1/2	560	0	0
5/8	46	13	8	1/8	308	0	0	5/8	569	6	16
3/4	56	0	0	1/4	317	6	16	3/4	578	13	8
7/8	65	6	16	3/8	326	13	8	7/8	588	0	0
1	74	13	8	1/2	336	0	0	8	597	6	16
1/8	84	0	0	5/8	345	6	16	1/8	606	13	8
1/4	93	6	16	3/4	354	13	8	1/4	616	0	0
3/8	102	13	8	7/8	364	0	0	3/8	625	6	16
1/2	112	0	0	5	373	6	16	1/2	634	13	8
5/8	121	6	16	1/8	382	13	8	5/8	644	0	0
3/4	130	13	8	1/4	392	0	0	3/4	653	6	16
7/8	140	0	0	3/8	401	6	16	7/8	662	13	8
2	149	6	16	1/2	410	13	8	9	672	0	0
1/8	158	13	8	5/8	420	0	0	1/8	681	6	16
1/4	168	0	0	3/4	429	6	16	1/4	690	13	8
3/8	177	6	16	7/8	438	13	8	3/8	700	0	0
1/2	186	13	8	6	448	0	0	1/2	709	6	16
5/8	196	0	0	1/8	457	6	16	5/8	718	13	8
3/4	205	6	16	1/4	466	13	8	3/4	728	0	0
7/8	214	13	8	3/8	476	0	0	7/8	737	6	16
3	224	0	0	1/2	485	6	16	10	746	13	8
1/8	233	6	16	5/8	494	13	8	1/8	756	0	0
1/4	242	13	8	3/4	504	0	0	1/4	765	6	16

ASSAY.	PER TON.			ASSAY	PER TON.			ASSAY.	PER TON.		
grs.	oz.	dwts.	grs.	grs.	oz.	dwts.	grs.	grs.	oz.	dwts.	grs.
10 ⅜	774	13	8	16	1194	13	8	⅝	1614	13	8
½	784	0	0	⅛	1204	0	0	¾	1624	0	0
⅝	793	6	16	¼	1213	6	16	⅞	1633	6	16
¾	802	13	8	⅜	1222	13	8	22	1642	13	8
⅞	812	0	0	½	1232	0	0	⅛	1652	0	0
11	821	6	16	⅝	1241	6	16	¼	1661	6	16
⅛	830	13	8	¾	1250	13	8	⅜	1670	13	8
¼	840	0	0	⅞	1260	0	0	½	1680	0	0
⅜	849	6	16	17	1269	6	16	⅝	1689	6	16
½	858	13	8	⅛	1278	13	8	¾	1698	13	8
⅝	868	0	0	¼	1288	0	0	⅞	1708	0	0
¾	877	6	16	⅜	1297	6	16	23	1717	6	16
⅞	886	13	8	½	1306	13	8	⅛	1726	13	8
12	896	0	0	⅝	1316	0	0	¼	1736	0	0
⅛	905	6	16	¾	1325	6	16	⅜	1745	6	16
¼	914	13	8	⅞	1334	13	8	½	1754	13	8
⅜	924	0	0	18	1344	0	0	⅝	1764	0	0
½	933	6	16	⅛	1353	6	16	¾	1773	6	16
⅝	942	13	8	¼	1362	13	8	⅞	1782	13	8
¾	952	0	0	⅜	1372	0	0	24	1792	0	0
⅞	961	6	16	½	1381	6	16	⅛	1801	6	16
13	970	13	8	⅝	1390	13	8	¼	1810	13	8
⅛	980	0	0	¾	1400	0	0	⅜	1820	0	0
¼	989	6	16	⅞	1409	6	16	½	1829	6	16
⅜	998	13	8	19	1418	13	8	⅝	1838	13	8
½	1008	0	0	⅛	1428	0	0	¾	1848	0	0
⅝	1017	6	16	¼	1437	6	16	⅞	1857	6	16
¾	1026	13	8	⅜	1446	13	8	25	1866	13	8
⅞	1036	0	0	½	1456	0	0	⅛	1876	0	0
14	1045	6	16	⅝	1465	6	16	¼	1885	6	16
⅛	1054	13	8	¾	1474	13	8	⅜	1894	13	8
¼	1064	0	0	⅞	1484	0	0	½	1904	0	0
⅜	1073	6	16	20	1493	6	16	⅝	1913	6	16
½	1082	13	8	⅛	1502	13	8	¾	1922	13	8
⅝	1092	0	0	¼	1512	0	0	⅞	1932	0	0
¾	1101	6	16	⅜	1521	6	16	26	1941	6	16
⅞	1110	13	8	½	1530	13	8	⅛	1950	13	8
15	1120	0	0	⅝	1540	0	0	¼	1960	0	0
⅛	1129	6	16	¾	1549	6	16	⅜	1969	6	16
¼	1138	13	8	⅞	1558	13	8	½	1978	13	8
⅜	1148	0	0	21	1568	0	0	⅝	1988	0	0
½	1157	6	16	⅛	1577	6	16	¾	1997	6	16
⅝	1166	13	8	¼	1586	13	8	⅞	2006	13	8
¾	1176	0	0	⅜	1596	0	0	27	2016	0	0
⅞	1185	6	16	½	1605	6	16	⅛	2025	6	16

ASSAY	PER TON.			ASSAY.	PER TON.			ASSAY	PER TON.		
grs.	oz.	dwts.	grs.	grs.	oz.	dwts.	grs.	grs.	oz.	dwts.	grs.
27 ¼	2034	13	8	32 ⅞	2454	13	8	38 ½	2874	13	8
⅜	2044	0	0	33	2464	0	0	⅝	2884	0	0
½	2053	6	16	⅛	2473	6	16	¾	2893	6	16
⅝	2062	13	8	¼	2482	13	8	⅞	2902	13	8
¾	2072	0	0	⅜	2492	0	0	39	2912	0	0
⅞	2081	6	16	½	2501	6	16	⅛	2921	6	16
28	2090	13	8	⅝	2510	13	8	¼	2930	13	8
⅛	2100	0	0	¾	2520	0	0	⅜	2940	0	0
¼	2109	6	16	⅞	2529	6	16	½	2949	6	16
⅜	2118	13	8	34	2538	13	8	⅝	2958	13	8
½	2128	0	0	⅛	2548	0	0	¾	2968	0	0
⅝	2137	6	16	¼	2557	6	16	⅞	2977	6	16
¾	2146	13	8	⅜	2566	13	8	40	2986	13	8
⅞	2156	0	0	½	2576	0	0	⅛	2996	0	0
29	2165	6	16	⅝	2585	6	16	¼	3005	6	16
⅛	2174	13	8	¾	2594	13	8	⅜	3014	13	8
¼	2184	0	0	⅞	2604	0	0	½	3024	0	0
⅜	2193	6	16	35	2613	6	16	⅝	3033	6	16
½	2202	13	8	⅛	2622	13	8	¾	3042	13	8
⅝	2212	0	0	¼	2632	0	0	⅞	3052	0	0
¾	2221	6	16	⅜	2641	6	16	41	3061	6	16
⅞	2230	13	0	½	2650	13	8	⅛	3070	13	8
30	2240	0	0	⅝	2660	0	0	¼	3080	0	0
⅛	2249	6	16	¾	2669	6	16	⅜	3089	6	16
¼	2258	13	8	⅞	2678	13	8	½	3098	13	8
⅜	2268	0	0	36	2688	0	0	⅝	3108	0	0
½	2277	6	16	⅛	2697	6	16	¾	3117	6	16
⅝	2286	13	8	¼	2706	13	8	⅞	3126	13	8
¾	2296	0	0	⅜	2716	0	0	42	3136	0	0
⅞	2305	6	16	½	2725	6	16	⅛	3145	6	16
31	2314	13	8	⅝	2734	13	8	¼	3154	13	8
⅛	2324	0	0	¾	2744	0	0	⅜	3164	0	0
¼	2333	6	16	⅞	2753	6	16	½	3173	6	16
⅜	2342	13	8	37	2762	17	8	⅝	3182	13	8
½	2352	0	0	⅛	2772	0	0	¾	3192	0	0
⅝	2361	6	16	¼	2781	6	16	⅞	3201	6	16
¾	3370	13	8	⅜	2790	13	8	43	3210	13	8
⅞	2380	0	0	½	2800	0	0	⅛	3220	0	0
32	2389	6	16	⅝	2809	6	16	¼	3229	6	16
⅛	2398	13	8	¾	2818	13	8	⅜	3238	13	8
¼	2408	0	0	⅞	2828	0	0	½	3248	0	0
⅜	2417	6	16	38	2837	6	16	⅝	3257	6	16
½	2426	13	8	⅛	2846	13	8	¾	3266	13	8
⅝	2436	0	0	¼	2856	0	0	⅞	3276	0	0
¾	2445	6	16	⅜	2865	6	61	44	3285	6	16

ASSAY.	PER TON.			ASSAY.	PER TON.			ASSAY.	PER TON.		
grs.	oz.	dwts.	grs.	grs.	oz.	dwts.	grs.	grs.	oz.	dwts.	grs.
44 ⅛	3294	13	8	49 ½	3696	0	0	54 ⅞	4097	6	16
¼	3304	0	0	⅝	3705	6	16	55	4106	13	8
⅜	3313	6	16	¾	3714	13	8	⅛	4116	0	0
½	3322	13	8	⅞	3724	0	0	¼	4125	6	16
⅝	3332	0	0	50	3733	6	16	⅜	4134	13	8
¾	3341	6	16	⅛	3742	13	8	½	4144	0	0
⅞	3350	13	8	¼	3752	0	0	⅝	4153	6	16
45	3360	0	0	⅜	3761	6	16	¾	4162	13	8
⅛	3369	6	16	½	3770	13	8	⅞	4172	0	0
¼	3378	13	8	⅝	3780	0	0	56	4181	6	16
⅜	3388	0	0	¾	3789	6	16	⅛	4190	13	8
½	3397	6	16	⅞	3798	13	8	¼	4200	0	0
⅝	3406	13	8	51	3808	0	0	⅜	4209	6	16
¾	3416	0	0	⅛	3817	6	16	½	4218	13	8
⅞	3425	6	16	¼	3826	13	8	⅝	4228	0	0
46	3434	13	8	⅜	3836	0	0	¾	4237	6	16
⅛	3444	0	0	½	3845	6	16	⅞	4246	13	8
¼	3453	6	16	⅝	3854	13	8	57	4256	0	0
⅜	3462	13	8	¾	3864	0	0	⅛	4265	6	16
½	3472	0	0	⅞	3873	6	16	¼	4274	13	8
⅝	3481	6	16	52	3882	13	8	⅜	4284	0	0
¾	3490	13	8	⅛	3892	0	0	½	4293	6	16
⅞	3500	0	0	¼	3901	6	16	⅝	4302	13	8
47	3509	6	16	⅜	3910	13	8	¾	4312	0	0
⅛	3518	13	8	½	3920	0	0	⅞	4321	6	16
¼	3528	0	0	⅝	3929	6	16	58	4330	13	8
⅜	3537	6	16	¾	3938	13	8	⅛	4340	0	0
½	3546	13	8	⅞	3948	0	0	¼	4349	6	16
⅝	3556	0	0	58	3957	6	16	⅜	4358	13	8
¾	3565	6	16	⅛	3966	13	8	½	4368	0	0
⅞	3574	13	8	¼	3976	0	0	⅝	4377	6	16
48	3584	0	0	⅜	3985	6	16	¾	4386	13	8
⅛	3593	6	16	½	3994	13	8	⅞	4397	0	0
¼	3602	13	8	⅝	4004	0	0	59	4406	6	16
⅜	3612	0	0	¾	4013	6	16	⅛	4415	13	8
½	3621	6	16	⅞	4022	13	8	¼	4424	0	0
⅝	3630	13	8	54	4032	0	0	⅜	4433	6	16
¾	3640	0	0	⅛	4041	6	16	½	4442	13	8
⅞	3649	6	16	¼	4050	13	8	⅝	4452	0	0
49	3658	13	8	⅜	4060	0	0	¾	4461	6	16
⅛	3668	0	0	½	4069	6	16	⅞	4470	13	8
¼	3677	6	16	⅝	4078	13	8	60	4480	0	0
⅜	3686	13	8	¾	4088	0	0				

A TABLE

SHEWING THE QUANTITY OF SILVER CONTAINED IN A TON OF LEAD OR ORE, BY ASSAY PRODUCED FROM FOUR OUNCES AVOIRDUPOIS.

ASSAY	PER TON.			ASSAY	PER TON.			ASSAY	PER TON.		
grs pts	oz.	dwts.	grs.	grs.	oz.	dwts.	grs.	grs.	oz.	dwts.	grs.
1/16	1	3	8	4	74	13	8	8	149	6	16
⅛	2	6	16	⅛	77	0	0	⅛	151	13	8
¼	4	13	8	¼	79	6	16	¼	154	0	0
⅜	7	0	0	⅜	81	13	8	⅜	156	6	16
½	9	6	16	½	84	0	0	½	158	13	8
⅝	11	13	8	⅝	86	6	16	⅝	161	0	0
¾	14	0	0	¾	88	13	8	¾	163	6	16
⅞	16	6	16	⅞	91	0	0	⅞	165	13	8
1	18	13	8	5	93	6	16	9	168	0	0
⅛	21	0	0	⅛	95	13	8	⅛	170	6	16
¼	23	6	16	¼	98	0	0	¼	172	13	8
⅜	25	13	8	⅜	100	6	16	⅜	175	0	0
½	28	0	0	½	102	13	8	½	177	6	16
⅝	30	6	16	⅝	105	0	0	⅝	179	13	8
¾	32	13	8	¾	107	6	16	¾	182	0	0
⅞	35	0	0	⅞	109	13	8	⅞	184	6	16
2	37	6	16	6	112	0	0	10	186	13	8
⅛	39	13	8	⅛	114	6	16	⅛	189	0	0
¼	42	0	0	¼	116	13	8	¼	191	6	16
⅜	44	6	16	⅜	119	0	0	⅜	193	13	8
½	46	13	8	½	121	6	16	½	196	0	0
⅝	49	0	0	⅝	123	13	8	⅝	198	6	16
¾	51	6	16	¾	126	0	0	¾	200	13	8
⅞	53	13	8	⅞	128	6	16	⅞	203	0	0
3	56	0	0	7	130	13	8	11	205	6	16
⅛	58	6	16	⅛	133	0	0	⅛	207	13	8
¼	60	13	8	¼	135	6	16	¼	210	0	0
⅜	63	0	0	⅜	137	13	8	⅜	212	6	16
½	65	6	16	½	140	0	0	½	214	13	8
⅝	67	13	8	⅝	142	6	16	⅝	217	0	0
¾	70	0	0	¾	144	13	8	¾	219	6	16
⅞	72	6	16	⅞	147	0	0	⅞	221	13	8

NOTE.

The following table (page 82) shews what proportion the silver found by assay in the foregoing tables bears to the ton of ore, and consequently will contribute greatly to assist the judgment of the refiner and amalgamator, respecting the treatment of the ore in smelting or amalgamizing.

A SUPPLEMENTARY TABLE TO THE FOREGOING,

SHEWING THE ALIQUOT PARTS OF A TON IN OUNCES, &c. FROM $\frac{1}{8}$ TO $\frac{1}{190}$

Aliquot parts.	WEIGHT.			Aliquot parts.	WEIGHT.			Aliquot parts.	WEIGHT.		
	oz.	dwts.	grs.		oz.	dwts.	grs.		oz.	dwts.	grs.
$\frac{1}{8}$	4480	0	0,0	$\frac{1}{36}$	995	11	2,7	$\frac{1}{64}$	560	0	0,0
$\frac{1}{9}$	3982	4	10,7	$\frac{1}{37}$	968	12	23,4	$\frac{1}{65}$	551	7	17,0
$\frac{1}{10}$	3584	0	0,0	$\frac{1}{38}$	943	3	3,8	$\frac{1}{66}$	543	0	14,5
$\frac{1}{11}$	3258	3	15,3	$\frac{1}{39}$	918	19	11,7	$\frac{1}{67}$	534	18	9,6
$\frac{1}{12}$	2986	13	8,0	$\frac{1}{40}$	896	0	0,0	$\frac{1}{68}$	527	1	4,2
$\frac{1}{13}$	2756	18	11,0	$\frac{1}{41}$	874	2	22,2	$\frac{1}{69}$	519	8	9,7
$\frac{1}{14}$	2560	0	0,0	$\frac{1}{42}$	853	6	16,0	$\frac{1}{70}$	512	0	0,0
$\frac{1}{15}$	2389	6	16,0	$\frac{1}{43}$	833	9	18,4	$\frac{1}{71}$	504	15	19,2
$\frac{1}{16}$	2240	0	0,0	$\frac{1}{44}$	814	10	21,8	$\frac{1}{72}$	497	15	13,3
$\frac{1}{17}$	2108	4	16,9	$\frac{1}{45}$	796	8	21,3	$\frac{1}{73}$	490	19	4,3
$\frac{1}{18}$	1991	2	5,3	$\frac{1}{46}$	779	2	14,6	$\frac{1}{74}$	484	6	11,7
$\frac{1}{19}$	1886	6	7,6	$\frac{1}{47}$	762	11	1,5	$\frac{1}{75}$	477	13	8,0
$\frac{1}{20}$	1792	0	0,0	$\frac{1}{48}$	746	13	8,0	$\frac{1}{76}$	471	11	13,9
$\frac{1}{21}$	1706	13	8,0	$\frac{1}{49}$	731	8	13,7	$\frac{1}{77}$	465	9	2,2
$\frac{1}{22}$	1629	1	19,7	$\frac{1}{50}$	716	16	0,0	$\frac{1}{78}$	459	9	17,8
$\frac{1}{23}$	1558	5	5,2	$\frac{1}{51}$	702	14	21,6	$\frac{1}{79}$	453	13	9,6
$\frac{1}{24}$	1493	6	16,0	$\frac{1}{52}$	689	4	14,8	$\frac{1}{80}$	448	0	0,0
$\frac{1}{25}$	1433	12	0,0	$\frac{1}{53}$	676	4	12,7	$\frac{1}{90}$	398	4	10,7
$\frac{1}{26}$	1378	9	5,5	$\frac{1}{54}$	663	14	1,8	$\frac{1}{100}$	358	8	0,0
$\frac{1}{27}$	1327	8	3,5	$\frac{1}{55}$	651	12	17,4	$\frac{1}{110}$	325	16	8,7
$\frac{1}{28}$	1280	0	0,0	$\frac{1}{56}$	640	0	0,0	$\frac{1}{120}$	298	13	8,0
$\frac{1}{29}$	1235	17	5,8	$\frac{1}{57}$	628	15	10,5	$\frac{1}{130}$	275	13	20,5
$\frac{1}{30}$	1194	13	8,0	$\frac{1}{58}$	617	18	14,9	$\frac{1}{140}$	256	0	0,0
$\frac{1}{31}$	1156	2	13,9	$\frac{1}{59}$	607	9	3,7	$\frac{1}{150}$	238	16	16,0
$\frac{1}{32}$	1120	0	0,0	$\frac{1}{60}$	597	6	16,0	$\frac{1}{160}$	224	0	0,0
$\frac{1}{33}$	1086	1	5,1	$\frac{1}{61}$	587	4	6,2	$\frac{1}{170}$	210	16	11,3
$\frac{1}{34}$	1054	2	8,5	$\frac{1}{62}$	578	1	6,9	$\frac{1}{180}$	199	2	5,3
$\frac{1}{35}$	1024	0	0,0	$\frac{1}{63}$	568	17	19,2	$\frac{1}{190}$	188	12	15,2

METHOD OF COMPUTING THE VALUE OF LEAD AND SILVER ORE.

EXAMPLE.

Required the value of 16 tons, 10 cwt. 2 qrs. of lead and silver ore, the produce for lead being 8⅝ in 20, and silver 3⅞ grs. from a four-ounce sample. The price of lead £22. per ton, and silver 5s. 3d. per oz. Returning charges £6. 10s. per ton, and lord's dues one-twelfth for lead, and one-eighth for silver.

OPERATION.

LEAD.

	ton	cwt.	qr.		£.	s.	d.
½	16	10	2				
			8				
	132	4	0				
¼	8	5	1				
	2	1	1				
*20)	142	10	2				
	7	2	2	at 15 10† per ton …………	110	2	6
				Deduct dues one-twelfth………………	9	3	6
					£100	19	0

OPERATION.

SILVER.

	oz.	dwt.	grs.	
By table, (page 81) produce 3⅞ is	72	6	16	per ton,

	tons	cwt.	qrs.		oz.	dwt.	grs.		oz.							
and	7	2	2	×	72	6	16	=	514	at 5s. 3d.	£134	18	6			
										Deduct dues one-eighth. . . .	16	17	4	£118	1	2
										Answer				£219	0	2

---

* It is not usual to make any allowance for waste on rich ores.

† Returning charge deducted.

METHOD OF COMPUTING THE VALUE OF COPPER ORE.

EXAMPLE.

What is the value of 74 tons, 13 cwt. 2 qrs. of copper ore, the produce, by assay, being 7⅛, and standard £127 12 6?

OPERATION.

	£.	s.	d.
⅛	127	12	6
			7
	893	7	6
	15	19	0¾
	9,09	6	6¾
	20		
	1,86		
	12		
	10,38		

THEN

	£.	s.	d.	
From	9	1	10	
Deduct	2	10	0	per ton returning charge.
	6	11	10	

Again If 1 ton : £6 11s. 10d. :: 74 tons . 13 cwt. . 2 qrs.

BY PRACTICE.

cwt.		£.	s.	d.
10½	½	6	11	10
				9
		59	6	6
				8
		474	12	0
		13	3	8
		487	15	8
		3	5	11
cwt. 3	1/7	0	18	10
Answer		492	0	5

Copper ores are always computed at 21 cwt. to the ton, the surplus being allowed for waste in carriage, &c.

RULE

FOR DISCOVERING THE POWER OF STEAM ENGINES.

1.—Square the diameter of the cylinder, multiply the sum by ,7854[*] and the product by 10 :[†] lastly multiply again by 144,[§] and the last product will shew the number of pounds the engine lifts a foot high in a minute.

2.—A horse is estimated to raise 500 lbs. 64 feet high, or 1000 lbs. 32 feet high, or 32000 lbs. 1 foot high in a minute, consequently if the last product be divided by 32000, the quotient will shew the number of horses required to equal the power of the engine.

EXAMPLE.

What is the power, and horse power of a steam engine, the cylinder being 46 inches in diameter?

46 × 46 = 2116
,7854
1661,9064
10
16619,0640
144
32000)2393145,2160(75
224000
153145
160000

lbs.
Answer { Engine lifts 2392145 one foot high in a minute.
Equal to 75 horses, nearly.

---

[*] The established ratio of the diameter. Or look in the table, page 89, where the square inches contained in a cylinder are given, and take out the number standing opposite the given diameter.

[†] That is, considering the power equal to 15 lbs. to an inch, and allowing 5 lbs. or one-third for friction.

[§] Considering the stroke to be 8 feet, and the engine to go 9 strokes per minute.

RULE

FOR DISCOVERING THE POWER OF A WATER ENGINE, VIZ:

1.—Multiply the length, breadth, and depth of the bucket together, and divide by 282, (the number of cubic inches in a gallon, beer measure) multiply the quotient by $\overset{\text{lbs.}}{10\tfrac{1}{5}}$ or $\overset{\text{lbs.}}{10}$. $\overset{\text{ozs.}}{3,2}$ or $\overset{\text{lbs.}}{10,2}$ the weight of a gallon of water.*

2.—Multiply the diameter of the wheel by 3,1416, (the ratio of the circle) and divide the product by the circular space occupied by each bucket—the quotient will shew the number of buckets contained in the wheel.

3.—Multiply the third part † of the number of buckets by the weight of water contained in one, then

4.—For the leverage—From the radius, or half the diameter, deduct the length of the crank, and one third of the remainder will be the operative length of the lever; multiply the weight of water in one-third of the wheel by this length, (taking the feet for the whole number of the multiplier) and the product will shew the full, or entire power. Lastly, from this product cast off $\tfrac{1}{5}$ for friction,§

---

* The result will be the same if the operation is done by the wine gallon, computing it to contain 231 cubic inches, and to weigh $\overset{\text{lbs.}}{8}$. $\overset{\text{ozs.}}{5,68}$ or $\overset{\text{lbs.}}{8,355}$.

† There are differences of opinion respecting this; some persons contending that two-fifth the number of buckets are full at a time, but one-third is the most general and the most reasonable proportion.

§ Here again engineers are not unanimously agreed, some allowing one-fifth, some one-fourth, and some even one-third of the power, for friction. It is true the distance the wheel is placed from the work, and other contingent circumstances must be taken into consideration, but in ordinary operations, where the wheel draws close, one-fifth is very near the truth.

and the remainder will shew the net or real power of the wheel.

EXAMPLE.

Required the power of a water-wheel, the diameter being 46 feet, the buckets 30 inches long, 12 inches deep, and 6 inches wide, with 1¼ inches between each bucket, and the crank 3 feet long.

OPERATION.

1.—To find the quantity and weight of water in each bucket.

$$30 \times 12 \times 6 = 2160 \div 282 = 7{,}66 \times 10{,}2 = 78{,}13.$$

2.—To find the number of buckets contained in the wheel.

$$46 \times 12 = 552 \times 3{,}1416 = 1734 \ (6 + 1\tfrac{1}{4}) \div 7{,}25 = 239.$$

3.—To find the weight of water on ⅓ of the wheel.

$$239 \div 3 = 80 \times 78{,}13 = 6250.$$

4.—To find the power of the lever.

$$46 \div 2 = 23 - 3 = 20 \div 3 = 6{,}66.$$

and

$$6250 \times 6{,}66 = 41{,}625.$$

Lastly for friction.

5)41625
8325

Answer 33300 lbs. the actual power of the wheel.

To find the depth at which a wheel will draw a column of water in a lift of pumps of any given dimensions.

RULE—Find the power of a wheel by the foregoing method, then from the table, page 91, take out the weight of water in a fathom of the given size pump. Divide the power of the wheel (in pounds) by this number, and the quotient will shew the fathoms.

EXAMPLE.

The power of the forementioned wheel is 33300 lbs. how deep will she draw in a 12 inch lift of pumps?

294,53)33300(113

Answer 113 fathoms.

TO FIND THE HORSE-POWER OF A WHEEL.

RULE—Multiply the power (found by the given rule, page 86) by the number of revolutions made by the wheel in a minute, and this product by the length of the stroke in feet, or double the length of the crank: divide the last product by 32000, and the quotient will shew the number of horses required to equal the power of the wheel.

EXAMPLE.

The forementioned wheel is allowed to make seven revolutions in a minute; required the horse-power.

```
                33300
                    7
               ------
               233100
                    6
         ------------
32,000) 1398,600 (44
        128
        ----
         118
         128
         ---
```

Answer 44 horse-power, nearly.

TABLE

SHEWING THE SQUARE INCHES CONTAINED IN A CYLINDER, FROM TEN TO SEVENTY-THREE INCHES IN DIAMETER.

Diameter of Cylinder.	SQUARE INCHES.	Diameter of Cylinder.	SQUARE INCHES.	Diameter of Cylinder.	SQUARE INCHES.	Diameter of Cylinder.	SQUARE INCHES.
10	78,54	26	530,93	42	1388,59	58	2642,00
11	95,03	27	572,56	43	1452,20	59	2734,00
12	113,10	28	615,75	44	1520,53	60	2827,44
13	132,73	29	660,20	45	1590,43	61	2922,47
14	153,94	30	706,86	46	1661,91	62	3019,00
15	176,71	31	754,77	47	1735,00	63	3117,25
16	201,06	32	804,25	48	1809,56	64	3217,00
17	226,98	33	855,30	49	1885,74	65	3318,31
18	254,47	34	907,92	50	1963,50	66	3421,20
19	283,54	35	962,00	51	2042,82	67	3526,66
20	314,16	36	1017,88	52	2123,72	68	3651,69
21	346,36	37	1075,20	53	2206,19	69	3739,29
22	380,13	38	1134,00	54	2290,23	70	3848,46
23	415,47	39	1194,60	55	2375,83	71	3959,20
24	452,39	40	1256,64	56	2463,00	72	4071,51
25	490,88	41	1320,26	57	2551,76	73	4185,40

NOTE.

The annexed table of the quantity and weight of water contained in 6 feet of pump, may be proved or extended by the following rules, viz.;

Square the diameter of the pump and multiply the product, first by the decimal ,7854, again by the length of the pump in inches, and divide by 231; the whole numbers in the quotient will shew the wine gallons. Then to find the cubic feet, divide the solid inches by 1728. Again to find the weight, multiply the cubic feet by 1000, and divide the product by 16.

EXAMPLE.

How many pounds, wine gallons, and cubic feet, are contained in a cylinder, or pump, 12 inches in diameter, and 6 feet in length?

TO FIND THE WINE MEASURE.

12 × 12 = 144 Square of diameter.
,7854 Multiplier.
113,0976
6
678,5856
12
Solid inches in a wine gallon.=231) 8143,0272 (35,2512
4
1,0048

Answer 35 gal, 1 qt.

TO FIND THE CUBIC FEET.

Inches in a cubic foot — 1728)8143,0272 Inches as before.
4,7124 Cubic feet,

TO FIND THE POUNDS.

4,7124 Cubic feet as before
1000 oz. weight of a cubic foot of water.
16)4712,4000
294,525 lbs. weight.

A TABLE

SHEWING THE WEIGHT, WINE GALLONS, AND CUBIC FEET OF WATER CONTAINED IN SIX FEET OF PUMP, FROM FOUR TO TWENTY INCHES IN DIAMETER.

Diameter of Pump.	WEIGHT.	WINE MEASURE.			CUBIC FEET.	Diameter of pump.	WEIGHT.	WINE MEASURE.			CUBIC FEET.
Ins.	lbs. dec.	gal.	qt.	pts.	ft. dec.	Ins.	lbs. dec.	gal.	qts.	pts.	ft. dec.
4	32,75	3	3	1	,522	12¼	306,95	36	2	1	4,910
4¼	36,95	4	1	1	,591	12½	319,60	38	1	0	5,113
4½	41,42	4	3	1½	,662	12¾	332,51	39	2	1	5,319
4¾	46,15	5	2	0	,738	13	345,68	41	1	1	5,530
5	51,14	6	0	1	,818	13¼	359,10	42	3	1	5,745
5¼	56,38	6	3	0	,902	13½	372,78	44	2	1	5,960
5½	61,87	7	1	1½	,989	13¾	386,72	46	0	1	6,187
5¾	67,63	8	0	0½	1,082	14	400,90	48	0	0	6,414
6	73,63	8	3	0	1,178	14¼	415,35	49	2	1	6,645
6¼	79,90	9	2	0	1,278	14½	430,00	51	1	1	6,880
6½	86,42	10	1	0	1,382	14¾	445,00	53	0	1	7,119
6¾	93,20	11	0	0	1,491	15	460,23	55	0	1	7,363
7	100,22	12	0	0	1,603	15¼	475,69	56	3	1	7,610
7¼	107,51	12	3	0	1,720	15½	491,42	58	3	0	7,862
7½	115,00	13	3	0	1,840	15¾	507,40	60	2	1	8,117
7¾	122,85	14	2	1	1,965	16	523,63	62	2	1	8,379
8	130,90	15	2	1	2,094	16¼	540,13	64	2	1	8,641
8¼	139,22	16	2	1	2,227	16½	556,87	66	2	1	8,909
8½	147,78	17	2	1	2,354	16¾	573,88	68	2	1	9,181
8¾	156,60	18	2	1	2,505	17	591,13	70	3	0	9,457
9	165,68	19	3	0	2,650	17¼	608,65	72	3	0	9,739
9¼	175,00	20	3	1	2,800	17½	626,42	75	0	0	10,022
9½	184,60	22	0	0	2,953	17¾	644,67	77	0	1	10,310
9¾	194,45	23	1	0	3,110	18	662,73	79	1	0	10,602
10	204,54	24	1	1	3,272	18¼	681,26	81	2	0	10,899
10¼	214,90	25	2	1	3,438	18½	700,00	83	3	0	11,142
10½	225,51	27	0	0	3,607	18¾	719,10	86	0	1	11,504
10¾	236,37	28	1	0	3,781	19	738,40	88	1	1	11,813
11	247,50	29	2	1	3,959	19¼	757,96	90	3	0	12,126
11¼	258,87	30	3	1	4,141	19½	777,78	93	0	1	12,443
11½	270,51	32	1	1	4,327	19¾	797,85	95	2	0	12,764
11¾	280,40	33	2	1	4,518	20	818,18	97	3	1	13,090
12	294,53	35	1	0	4,712						

A TREATISE

ON THE QUALITY, MANUFACTURE, AND CHOICE OF CORDAGE, FOR MINING PURPOSES, WITH RULES AND TABLES FOR THE WEIGHT AND NUMBER OF THREADS CONTAINED IN ANY SIZE ROPE.

IT is certainly very desirable, if not absolutely necessary, that every person who is entrusted with the management of a mine, should possess some means of obtaining with a degree of certainty, the quality and weight of the ropes he may have occasion to use; otherwise the lives and property entrusted to his care will be continually placed in jeopardy, and his employers be always subject to impositions respecting the charge; because in many cases (from the magnitude of the material) it cannot be weighed, and therefore its weight can only be ascertained by computation; consequently, if the agent is ignorant of the matter, the right of the adventurers will solely depend on the truth of the manufacturer's calculation.

The following tables will enable the agent to find the weight of any rope, and the ensuing remarks will help his judgment respecting the quality thereof; being far the most important part of the subject.

There are various methods of discovering the quality of hemp; but as miners have seldom an opportunity of inspecting the article in this stage of preparation, we shall pass on, and shew how it may be proved after its having been completely manufactured.

The first thing that demands our particular attention is, the size of the yarn or thread of which the rope is composed. There is a certain gauge or standard for this, known among ropemakers by the terms, sixteens, eighteens, twenties &c. which means 16, 18, or 20 yarns in the strand, or third part of a rope 3 inches in circumference. The following table shews the weight of the different sizes of yarn before it has gone through the operation of tarring.

SIZE.	LENGTH.	WEIGHT.	
		lbs.	*ozs.*
25	170 fathoms	2	18
20		3	8
18		3	15
16		4	6
15		4	10

Now the true standard size for shroud-laid rope is *twenties*,* and it is of consequence that agents should give their orders accordingly, and afterwards be assured that their ropes have really been made with yarns of this gauge.

In order to prove this, first, girt the circumfererence of the rope, then count the yarns in the strand, and lastly refer to the table (page 101) and note if the number corresponds with that standing in the proper column, opposite the dimensions of the rope.

---

* Of which it is shewn in the above table that 170 fathoms weighs only 3 lbs. 8 oz. or 3½ lbs.

Manufacturers have many inducements for spinning their yarn large. First,—It is less expensive, for it requires no more time to spin a large yarn than to spin a small one, and 16 or 17 yarns (in their way) will answer the end of twenty. Secondly,—In large yarns, inferior or refuse hemp can be spun, which cannot be done in yarns of a smaller size; and this consideration, if there was no other, should cause the agent to be exceedingly particular in having his rope made of standard yarns: and let it be remarked that although a rope made of sixteens, or eighteens will be nearly equal in weight to another made of twenties, yet by no means will it be equal in strength, even if made of the very same kind, or indeed of superior hemp. This is too plain a truth to need any illustration: for though it may be argued that what is wanting in number is made up in bulk, yet, it will support an equal weight no more, in proportion, than a body of raw hemp the size of a cable will be as strong as the cable itself.

By inspecting the table (page 101) it will be seen that the strand of a 16-inch capstan-rope made of twenties, contains 569 yarns, but if made of sixteens, only 455 yarns; making a difference in the whole rope of 342 yarns.

We shall now give a plain and expeditious, though infallible method, of proving the quality of hemp and yarn, viz.:—From the end, or *fag* of the rope, cut several of the yarns in fathom lengths, each of these, (standard size) should suspend, or bear up separately, 70 pounds weight at the least.

Regard must next be paid to the last part of the manufacture, called the *lay*, or twist of the rope, and this should undergo a strict examination, as much depends on the skill and attention of the manufacturer in this part of the process; for it is very possible that the best materials may be used, the yarn spun of the proper size, and with the greatest care, and yet the rope be very defective, and by no means fit to be depended on. This may be easily discovered when the rope is laid in a straight line; then, if either of the strands is observed to mount or fall,* that is, rise above or sink beneath the others in any degree, the rope has been *crippled*, or inevitably spoiled; for, if the former case, of one strand rising, in the event of trial, that strand will be found to bear little or none of the weight, when the other two will break; and, in the latter case, of one strand sinking, that strand will break before the other two have been brought to the strain, or have borne any considerable part of the weight.

These great defects in cordage are too often to be found, and almost as often pass unobserved; but they may always be detected by a close inspection, and thereby many of the serious injuries and fatal accidents which so often take place in mining be happily prevented.

We shall close these observations, after remarking that as nearly all cordage used in mining is much exposed to the alternate influence of sun and moisture, which tends greatly to accelerate its decay; it ought by all means to contain a greater quantity of tar than is generally used. The common rule is 1 to 5½, or 1 to 6; but the proportion of 1 to 4½ or 1 to 5 would be much better: but we recommend this increase for standing ropes only, such as capstan-ropes, &c.; as from the comparative unfrequency of their use, and the length of time they endure, are equally liable to injury from mould and decay, as from strain and friction.

---

* This fault or defect is known among ropemakers by the term "pinch," and as the remedy occasions a great deal of trouble and delay, it is too often suffered to pass, especially as few persons are able to detect it, or are aware of its injurious tendency.

The common practice of tarring the surface of the rope after it has been manufactured, is of very little service: the way we recommend is, by reducing the ordinary weight suspended to the lever, during the process of tarring the yarn in the manufactory, when it is drawn in a body from the heated coppers through the knipper; whereby the tar being lodged in the internal part of the rope, cannot fail of preserving it under all circumstances.

The following rules, examples, and tables, will be found plain, convenient, and correct.

There are many casual occurrences whereby ropes are exposed to injuries in mines, out of the common course of working—we may notice an instance or two, viz.: inattention or ignorance in taking them from the coil when new—they should always be taken out the contrary way from which they were coiled in; that is, if a capstan-rope is coiled into a waggon, the uppermost end should be put down and drawn from the under part of the carriage: also, in small cordage, the inward extremity of the rope should be taken and drawn through the aperture of the reel. The general disproportion of capstan gear in mines has a most destructive effect on the ropes; the sheaves or *pulleys*, as well as the *milliar* of the capstan, being considerably too small; indeed there is still room for much improvement in this part of mining machinery.

TO FIND THE NUMBER OF THREADS IN A SHROUD-LAID* ROPE.

RULE—State the question as in direct proportion, square the first and third terms, multiply the second and third terms together, and divide the product by the first,

EXAMPLE.

How many standard yarns, or threads, are there in a 14-inch capstan rope?

in. yarns. in.
As 3 : 20 :: 14
3 14
9 56
14
196
20
9) 3920
435

Ans. 435 threads in the strand.
3
or 1305 threads in the rope.

EXAMPLE.

How many standard yarns are there in a 9½ inch rope?

in. yarn. in.
As 3 : 20 :: 9,5
3 9,5
9 475
855
90,25
20
9) 1805,00
Answer 200, threads in the strand.
3
600 threads in the rope.

---

* The term "shroud-laid" is used to distinguish a rope of three strands or parts from another of nine strands, which is termed "cable-laid."—The latter may be said to be 3 shroud-laid ropes twisted together. It is seldom that any other but three-strand ropes are used in mines.

TO FIND THE WEIGHT OF SHROUD-LAID ROPES.

RULE—State the question and square the numbers as in the last example.

EXAMPLE.

If 1 cwt. of 3-inch rope measures 54 fathoms,* what will be the length of an cwt. of a 12-inch rope.

```
    in.       fath.
As  3    :     54      : :    12
    3           9             12
   ---        ---            ---
    9   144) 486  (3,375     144
             432      6
            ---    -----
             540   2,250
             432      12
            ----   -----
             1080  3,000
             1008
             ----
              720           fath.  ft.  in.
              720       Ans. 3  .  2  .  3
             ====
```

EXAMPLE.

If 100 fathoms of 3-inch rope weighs $\overset{\text{cwt.}}{1}$. $\overset{\text{qrs.}}{3}$. $\overset{\text{lbs.}}{11,3}$, what will be the weight of a 15-inch rope the same length.

```
    in.        cwt. qrs.  lbs.
As  3    :     1 . 3 . 11,3    : :    15
    3          4                      15
   ---        ---                    ---
    9          7                      75
              28                     15
             -----                   ---
             207,3                   225
               225
          ---------
        9) 46642,5
      112)  5182 (46
            448
            ---
             702
             672
             ---                cwt.  qr.  lb.
              30           Ans. 46  .  1  .  2
             ====
```

---

* The length of standard yarn to a lb. is $\overset{\text{fath.}}{43}$. $\overset{\text{ft.}}{2}$. $\overset{\text{in}}{4,3}$ after it has been tarred, and 54 fathoms of 3-inch rope are exactly 1 cwt.—by this rule the following tables have been constructed. It must be recollected that this computation is made, estimating the proportion of tar 1 to 5½ only.

TO FIND THE WEIGHT OF ROPES BEING 120 FATHOMS IN LENGTH.

RULE—Divide the circumference of the rope by 2, and square the remainder. *

EXAMPLE.

What is the weight of a 12-inch rope 120 fathoms long.

```
2) 12
   ---
    6
    6
   ---
Answer  36 cwt.
```

EXAMPLE.

What is the weight of a 14½-inch rope 120 fathoms long?

```
2) 14,5
   -------
     7,25
     7,25
   -------
  52,5625
        4
   -------
   2,2500
      28
   -------
     200
     50
   -------
    7,0000
```

Answer cwt. 52 . qrs. 2 . lbs. 7

---

* This rule is not perfectly accurate, but may be useful in affording a clue for finding the approximate weight of ropes, especially if the circumference is in even numbers, it may then be used mentally, or by the mind only.

TABLE 1.

SHEWING THE NUMBER OF THREADS IN THE STRAND OF A SHROUD-LAID ROPE.

SIZE OF ROPE.	SIZE OF YARN. SIXTEENS.	SIZE OF YARN. TWENTIES.	SIZE OF ROPE.	SIZE OF YARN. SIXTEENS	SIZE OF YARN. TWENTIES.
Inches.	No.	No.	Inches.	No.	No.
2	7	9	9½	160	200
2½	10	14	10	177	222
3	16	20	10½	196	245
3½	21	27	11	215	268
4	28	35	11½	235	293
4½	36	45	12	256	320
5	44	55	12½	278	347
5½	53	67	13	300	375
6	64	80	13½	324	405
6½	75	93	14	348	435
7	87	109	14½	374	467
7½	100	125	15	400	500
8	113	142	15½	427	533
8½	128	160	16	455	569
9	144	180	16½	484	605

The difference of the number of threads in the whole rope will be found by subtracting the numbers standing under "sixteens" from those under "twenties," and multiplying the remainder by 3. (Thus 256—320=64×3=192.) Therefore it appears that a 12-inch rope made of "twenties" contains 192 threads more than another, of the same circumference, made of "sixteens."

TABLE 2.

SHEWING THE LENGTH OF SHROUD-LAID ROPES TO AN CWT. FROM 1 TO 16 INCHES IN CIRCUMFERENCE.

SIZE OF ROPE.	FATH.	FEET.	INS.	SIZE OF ROPE	FATH.	FEET.	INS.
1 in.	486	0	0,0	9 in.	6	0	0
1½	216	0	0,0	9½	5	2	3,7
2	121	3	0,0	10	4	5	1,9
2½	77	4	6,7	10½	4	2	5,4
3	54	0	0,0	11	4	0	1,2
3½	39	4	0,0	11½	3	4	0,9
4	30	2	3,0	12	3	2	3
4½	24	0	0,0	12½	3	0	7,9
5	19	2	7,7	13	2	5	3,1
5½	16	0	4,3	13½	2	3	11,5
6	13	3	0,0	14	2	2	10,4
6½	11	3	0,0	14½	2	1	10,4
7	9	5	6,2	15	2	0	11,5
7½	8	3	10,0	15½	2	0	1,4
8	7	3	6,7	16	1	5	4,6
8½	6	4	4,3	16½	1	4	8,5

The exact weight of a rope of any length may be found by the above table and the rule of proportion.

EXAMPLE.

Required the weight of 25 fathoms of 14-inch rope?

fath. ft. in. cwt. fath.
As 2 . 2 . 10,4 : 1 : : 25
6 6
14 150
12 12
178,4 178,4) 1800 (10,09
4
36
28
10,08

cwt. qrs. lbs.
Answer 10 . 0 . 10

TABLE 3.

SHEWING THE WEIGHT OF SHROUD-LAID ROPES 100 FATHOMS IN LENGTH.

SIZE OF ROPE.	CWT.	QRS.	LBS.
3 ins.	1	3	11,3
4	3	1	4
5	5	0	15
6	7	1	16
7	10	0	7
8	13	0	19
9	16	2	15
10	20	2	4
11	24	3	11
12	29	2	14
13	24	3	3
14	40	1	12
15	46	1	2
16	52	2	22

NOTE.

The weight of any length of rope may be found by the above table and the rule of practice.

EXAMPLE.

What is the weight of 47 fathoms of 11 inch rope?

		cwt.	qrs.	lbs.
25	$\frac{1}{4}$	24	3	11
		6	0	24
20	$\frac{1}{5}$	4	3	24
2	$\frac{1}{10}$	0	1	27
Ans.		11	2	19

The weight and circumference of any rope being given, the length may be found by the foregoing table and the common rule of proportion, or by decimals.

EXAMPLE.

What is the length of 7 cwt. . 3 qrs. . 14 lbs. of 7-inch rope?

	cwt. qrs. lbs.		fath.		cwt. qrs. lbs.
As	10 . 0 . 7	:	100	: :	7 . 3 . 14
	4				4
	40				31
	4				4
	161				126
					100
				161)	12600
					78,26

OTHERWISE.

	cwt.		fath.		cwt.
As	10,0625	:	100	: :	7,875
					100
				10,0625)	787,500
					78,26
					6
					1,56
	fath. ft. in.				12
	Answer 78 . 1 . 6				6,72

Or the length of any rope may be known by the 2nd table and the rule of practice.

EXAMPLE.

What is the length of 16 cwt. . 2 qrs. . 21 lbs. of a 10½-inch rope?

		fa.	ft.	in.	
	½	4 .	2 .	5,4	to an cwt. by the table.
				8	
		35 .	1 .	7,2	
				2	
		70 .	3 .	2,4	
	¼	2 .	1 .	2,7	
	½	0 .	3 .	3,6	
		0 .	1 .	7,8	
Answer		73 .	3 .	4,5	

OBSERVATIONS

ON THE CONSTRUCTION OF MINING CAPSTAN AND SHEARS.

It has been noted that there remains much room for improvement in the capstan machinery of our mines, consequently it will not be irrelevant to the foregoing treatise, briefly to submit our ideas on the subject in this place.

By the present apparatus a capstan rope of 14 or 16 inches in circumference is drawn over a single pulley, on the top of the shears, two feet in diameter, or thereabout, from whence it is brought down nearly to the foot, and then conducted under another pulley to the axle or barrel of the capstan; a cylinder seldom exceeding 2½ feet in diameter.

The violence done to the rope, in lifting great weights, as well as the augmentation of friction, in consequence of these sudden turns or incurvities, is certainly greater than has been generally understood, but reflection and experience combine to teach us, that at all these bends or flexures a considerable proportion of the number of threads contained in the rope, contribute nothing towards the support of the suspended weight; the outermost part of the cordage, from the grove of the pulley, necessarily bearing the whole strain.

The excess of friction is chiefly produced by the lay or twist of the rope, it having thereby an innate and unconquerable tendency to resist the constraint of being forced into a small curve, consequently the less scope it has the more power will be required.

These arguments are self-evident, and no doubt but the inconveniencies alluded to, and many more, are partially known and acknowledged, but the question is, how can they be remedied? we respectfully submit the following proposition. First, let the uprights of the shears stand farther apart on the top than usual, and the cap or head-piece of a convex shape, so that it may admit 3 pulleys in a triangular position,* the side pulleys horizontal, and the middle one standing higher than the others; then let a sheave be introduced in a channel in the leg of the shears next the capstan, about one third down from the cap, another in the stay of the span-beam projecting 3 or 4 feet from the leg, and the last pulley placed in a strong post fixed about 14 feet from the foot of the shears, in a direct line and parallel with the axle of the capstan. †

By this simple contrivance it may be reasonably conjectured that one rope will endure as long as two, and a 14 be equal to a 16-inch on the old plan; and as the latter, 100 fathoms long, is above 12 cwt. heavier than the former, of course that superfluity will be avoided both in cost and gravity: ‡ the shears will stand more erect than usual, whereby their height and strength will evidently be increased.

We profess to know but little of the science of mechanics, nevertheless we feel confident that the foregoing proposition is quite practicable and the subject is sufficiently important to demand consideration: we hope to see the hint improved and carried into effect by some of our ingenious engineers.

---

* Or a straight piece may be used for the cap, letting the centre pulley be large and the side ones small; but a semicircular cap with 5 small pulleys (one on the top and two on each side) will be still preferable.

† The barrel of the capstan should be made proportionally larger, and the arms or bars of a corresponding length.

‡ The safety, as well as convenience and economy of this plan, is too apparent to be overlooked.

EXPLANATION OF TERMS USED IN THE FOREGOING WORK.

Acclivity, the rising steepness of a hill.

Aliquot, such a part of a number or quantity as is contained in it so many times without a remainder.

Angle, the space between two lines which cross each other.

Base, the bottom, the foundation.

Bisect, to divide into two parts.

Complement, so much of an angle as is wanting to make a right angle.

Construction, the contriving such lines and figures as will shew the truth of a problem.

Corollary, conclusion drawn from antecedent demonstration.

Cosecant, the secant of the complement of an arch to 90 degrees.

Cosine, the right sine of an arch which makes up another arch of 90 degrees.

Cotangent, the tangent of an arch which is the complement of another arch to 90 degrees.

Declination, the act of bending.

Declivity, the steepness of a hill downwards, gradual descent.

Definition, a clear and short description.

Degree, the 360th part of the arc of a circle.

Demonstrate, to prove with certainty.

Denomination, a name given to any thing.

Depression, the act of pressing down.

Desideratum, a desirable improvement in a science yet unattained.

Diagonal, a line drawn from one angle to another.

Diagram, a scheme drawn for the explanation of any thing.

Elevation, a raising or lifting up.

Geometry, the science of extension.

Horizon, the line that bounds the visible from the invisible part of the earth.

Horizontal, level with the horizon.

Hypothenuse, the longest side of a right-angled triangle.

Inaccessible, not to be approached.

Intersect, to cut each other.

Intervene, to come between.

Junction, the act of joining together.

Mathematics, that science which contemplates whatever is capable of being numbered or measured.

Oblique, not perpendicular, not parallel.

Perpendicular, a line that stands upon or crosses another at right angles.

Problem, that which proposes something to be done.

Protractor, an instrument to lay down or measure angles.

Quadrant, one-fourth part of a circle containing 90 degrees.

Radius, a right line drawn from the centre to the circumference of a circle, half the diameter.

Right Angle, an angle containing 90 degrees, made by the touch of two lines perpendicular to each other.

Scale, a mathematical instrument containing lines divided into equal or unequal parts.

Scheme, a plan, a mathematical diagram.

Secant, a right line drawn from the centre of a circle that meets the tangent.

Segment, a part cut off.

Sine, a right line drawn from one end of an arc perpendicular upon the diameter.

Summary, compendium, abridgment.

Tabular, set down in tables.

Theorem a position laid down as an acknowledged truth.

Tangent a right line drawn without a circle perpendicular to some radius.

Triangle, a figure having three sides and angles.

Trigonometry, the science of resolving triangles.

Trisection, division into three parts.

Vertical, perpendicular to the horizon.

FINIS.

Byers, Printer, Devonport.

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